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REPORT No. 481 c.3

WORKING CHARTS FOR THE DETERMINATION OF PROPELLER THRUST AT VARIOUS AIR SPEEDS

By EDWIN P. HARTMAN

1934

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AERONAUTIC SYMBOLS

1. FUNDAMENTAL AND DERIVED UNITS

	Symbol	Metric		English	
		Unit	Abbreviation	Unit	Abbreviation
Length	l	meter	m	foot (or mile)	ft. (or mi.)
Time	t	second	s	second (or hour)	sec. (or hr.)
Force	F	weight of 1 kilogram	kg	weight of 1 pound	lb.
Power	P	horsepower (metric)		horsepower	hp.
Speed	V	kilometers per hour	k.p.h.	miles per hour	m.p.h.
		meters per second	m.p.s.	feet per second	f.p.s.

2. GENERAL SYMBOLS

W, Weight $=mg$

g, Standard acceleration of gravity $=9.80665$ m/s^2 or 32.1740 ft./sec.^{2}

m, Mass $=\frac{W}{g}$

I, Moment of inertia $=mk^2$. (Indicate axis of radius of gyration k by proper subscript.)

μ, Coefficient of viscosity

ν, Kinematic viscosity

ρ, Density (mass per unit volume)

Standard density of dry air, 0.12497 kg-m^{-4}-s^2 at 15° C. and 760 mm; or 0.002378 lb.-ft.$^{-4}$ sec.^{2}

Specific weight of "standard" air, 1.2255 kg/m^3 or 0.07651 lb./cu.ft.

3. AERODYNAMIC SYMBOLS

S, Area

S_w, Area of wing

G, Gap

b, Span

c, Chord

$\frac{b^2}{S}$, Aspect ratio

V, True air speed

q, Dynamic pressure $=\frac{1}{2}\rho V^2$

L, Lift, absolute coefficient $C_L=\frac{L}{qS}$

D, Drag, absolute coefficient $C_D=\frac{D}{qS}$

D_o, Profile drag, absolute coefficient $C_{D_o}=\frac{D_o}{qS}$

D_i, Induced drag, absolute coefficient $C_{D_i}=\frac{D_i}{qS}$

D_p, Parasite drag, absolute coefficient $C_{D_p}=\frac{D_p}{qS}$

C, Cross-wind force, absolute coefficient $C_C=\frac{C}{qS}$

R, Resultant force

i_w, Angle of setting of wings (relative to thrust line)

i_t, Angle of stabilizer setting (relative to thrust line)

Q, Resultant moment

Ω, Resultant angular velocity

$\rho\frac{Vl}{\mu}$, Reynolds Number, where l is a linear dimension (e.g., for a model airfoil 3 in. chord, 100 m.p.h. normal pressure at 15° C., the corresponding number is 234,000; or for a model of 10 cm chord, 40 m.p.s. the corresponding number is 274,000)

C_p, Center-of-pressure coefficient (ratio of distance of *c.p.* from leading edge to chord length)

α, Angle of attack

ϵ, Angle of downwash

α_o, Angle of attack, infinite aspect ratio

α_i, Angle of attack, induced

α_a, Angle of attack, absolute (measured from zero-lift position)

γ, Flight-path angle

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By EDWIN P. HARTMAN
Langley Memorial Aeronautical Laboratory

46924—34——1

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REPORT No. 481

WORKING CHARTS FOR THE DETERMINATION OF PROPELLER THRUST AT VARIOUS AIR SPEEDS

By Edwin P. Hartman

SUMMARY

A set of propeller performance charts, based on a "torque speed" coefficient C_{QS}, *has been constructed from full-sized metal propeller data obtained in the N.A.C.A. propeller-research tunnel.*

The simplifying assumption that the torque of the engine remains constant (which appears to be nearly true except for highly supercharged engines) is utilized in the application of the coefficient C_{QS} *which is defined as follows:* $C_{QS}=\frac{V}{n\,D}\sqrt{\frac{1}{C_Q}}=V\sqrt{\frac{\rho D^3}{Q}}$ *from which the troublesome variable* n *(engine revolution speed) has been eliminated. The coefficient* C_{QS} *when plotted against the ratio* C_T/C_Q, *which is equal to* TD/Q, *provides a useful chart from which propeller thrust may be quickly calculated for any air speed. Twenty-four tables are included to present the data from which the charts previously published in Technical Report No. 350 were obtained.*

INTRODUCTION

In the construction of working charts for propeller-performance calculations, utility is and should be of first importance. The usefulness of any propeller chart is often largely a function of the form of coefficients used in its construction.

Owing to the large number of variables involved in propeller calculations it is nearly impossible to devise one coefficient suitable for all phases of propeller work; for example, the charts given in N.A.C.A. Technical Report No. 350 (reference 1) based on the coefficient C_S and charts from other sources based on similar coefficients, although eminently suitable for the selection of propellers, are not entirely suitable for calculating propeller performance at low air speeds.

The growing importance of take-off considerations for seaplanes and high-speed landplanes has emphasized the need for appropriate data and methods with which to calculate propeller thrust in the take-off range.

With this need in mind a set of propeller-performance charts based on a coefficient C_{QS} has been prepared from the same propeller test data that were used in reference 1. These charts, while of little use in selecting propellers, are well adapted for calculating propeller performance not only in the take-off range but in the whole full-throttle flight range.

The coefficient C_{QS} and the method of calculating propeller thrust given in this report were suggested by Mr. J. M. Shoemaker of the N.A.C.A. tank staff.

APPARATUS AND METHODS

The propeller data used in reference 1 and also in this report were taken in the N.A.C.A. propeller-research tunnel, a description of which is given in reference 2. A brief description of the apparatus and methods used in obtaining the original data will be given here; if more detailed information is desired, it may be obtained from reference 1.

The tests were made with a 9-foot diameter adjustable metal propeller having Navy plan form no. 4412. The propeller was set 11.5°, 15.5°, 19.5°, 23.5°, and 27.5° at 0.75 radius and tested in conjunction with each of the six different engine-fuselage combinations listed below.

No. 1—Open cockpit fuselage with 400 hp. Curtiss D–12 engine (fig. 1).

No. 2—Complete VE–7 airplane with 180-hp. Wright E–2 water-cooled engine with nose radiator (fig. 2).

No. 3—Open cockpit fuselage with Wright Whirlwind J–5 9-cylinder radial engine (fig. 3).

No. 4—Cabin fuselage with monoplane wing and J–5 engine (fig. 4).

No. 5—Cabin fuselage without wing and with J–5 engine (fig. 5).

No. 6—Cabin fuselage with J–5 engine and N.A.C.A. engine cowling (fig. 6).

In each case the engine was mounted on a torque dynamometer enclosed in the fuselage. The power output of the engine was calculated from dynamometer readings after a correction based on special tests (see reference 1) had been made to allow for the effect of propeller-slipstream torque on the projecting engine cylinders. The resultant horizontal force and the engine revolution speed were also measured.

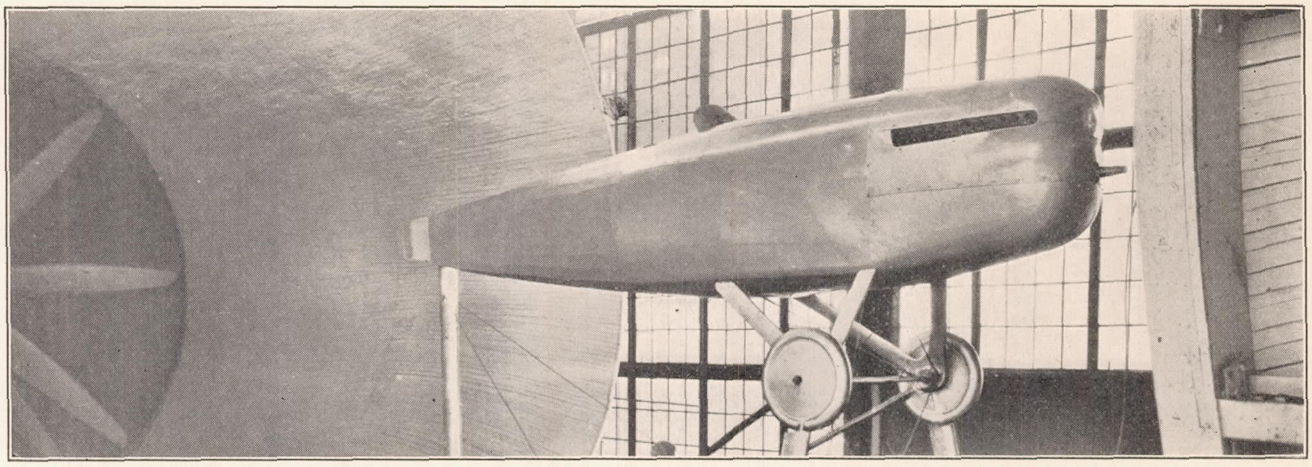

FIGURE 1.—Open-cockpit fuselage with 400-horsepower Curtiss D-12 engine.

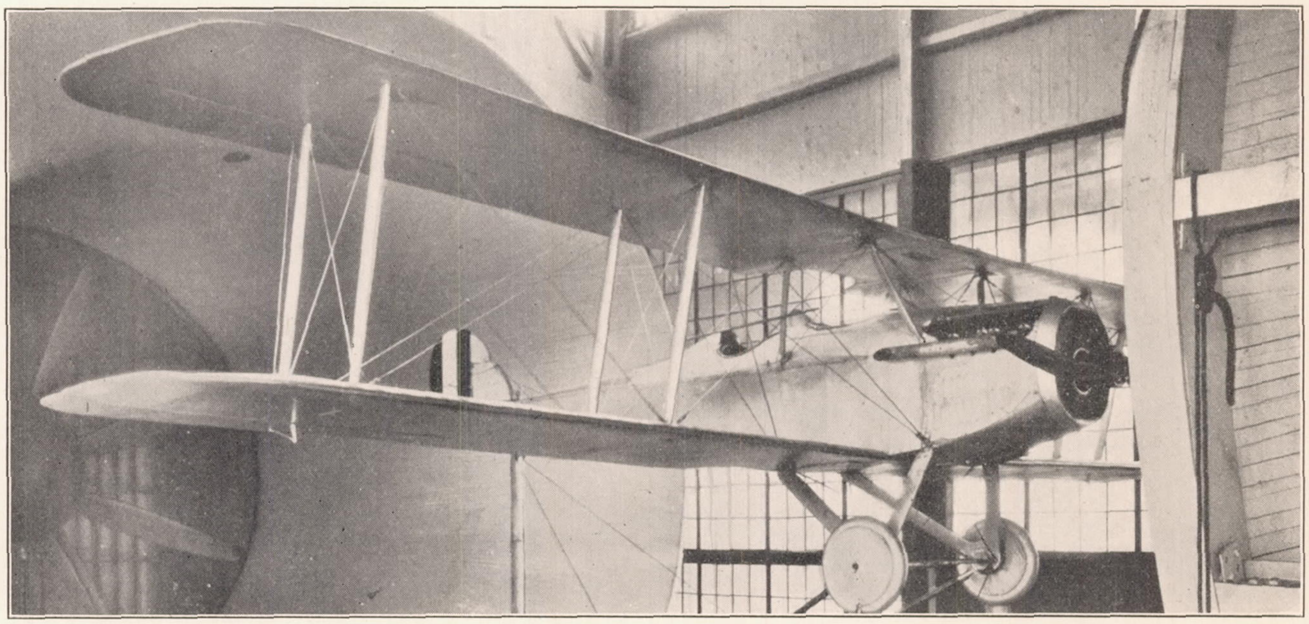

FIGURE 2.—Complete VE-7 airplane with 180-horsepower Wright E-2 water-cooled engine with nose radiator.

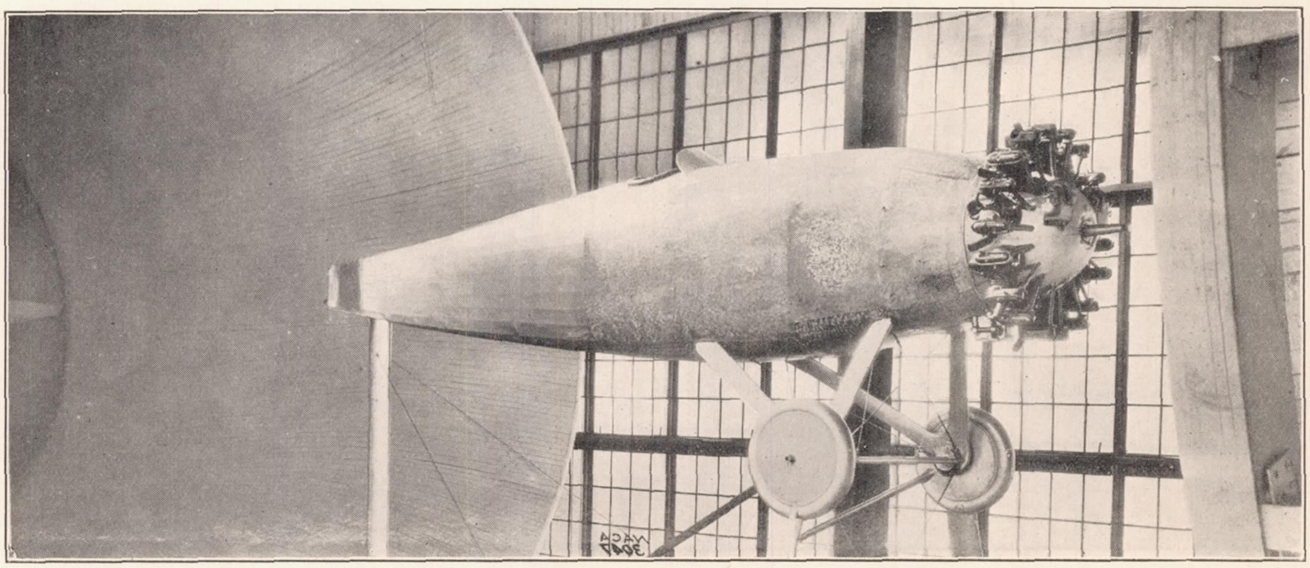

FIGURE 3.—Open-cockpit fuselage with Wright Whirlwind J-5 9-cylinder engine.

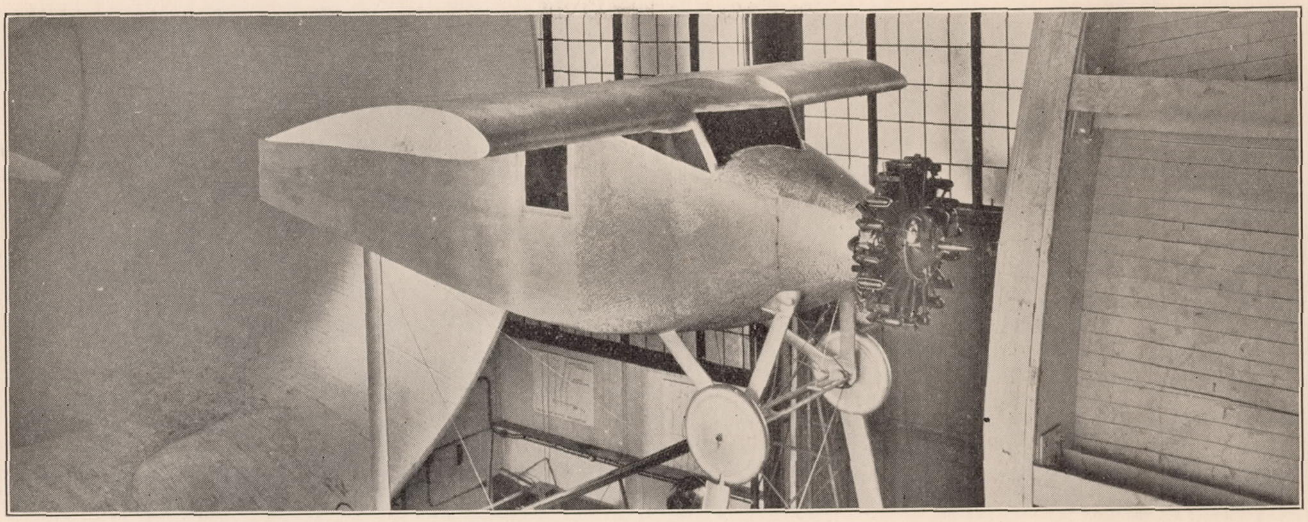

FIGURE 4.—Cabin monoplane with J–5 engine.

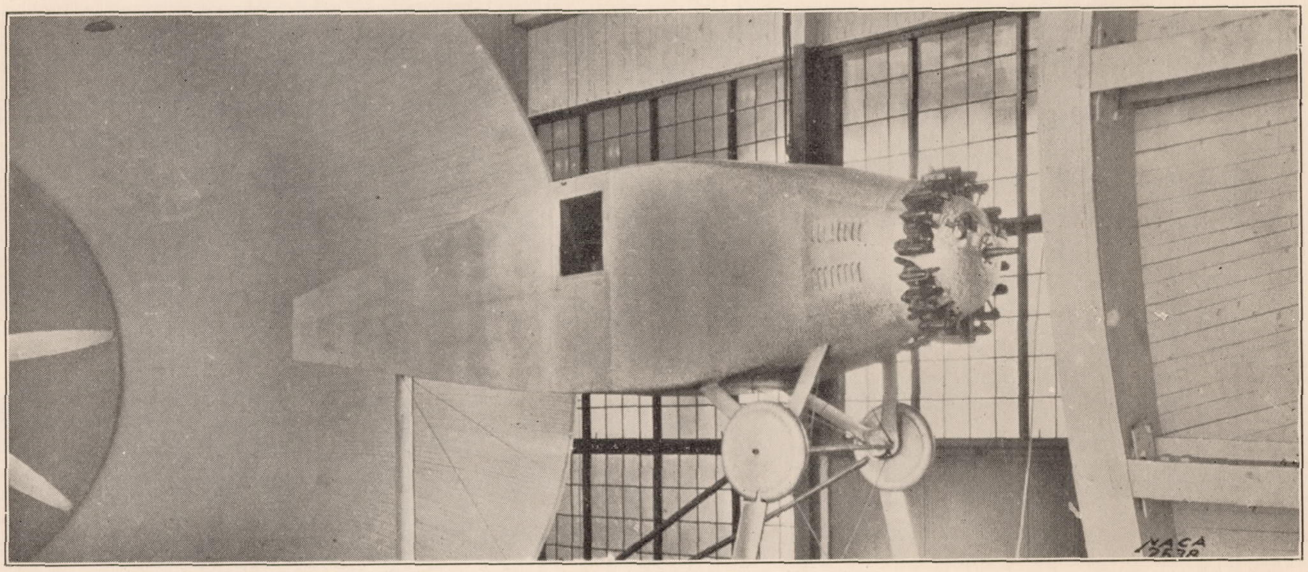

FIGURE 5.—Cabin fuselage with J–5 engine.

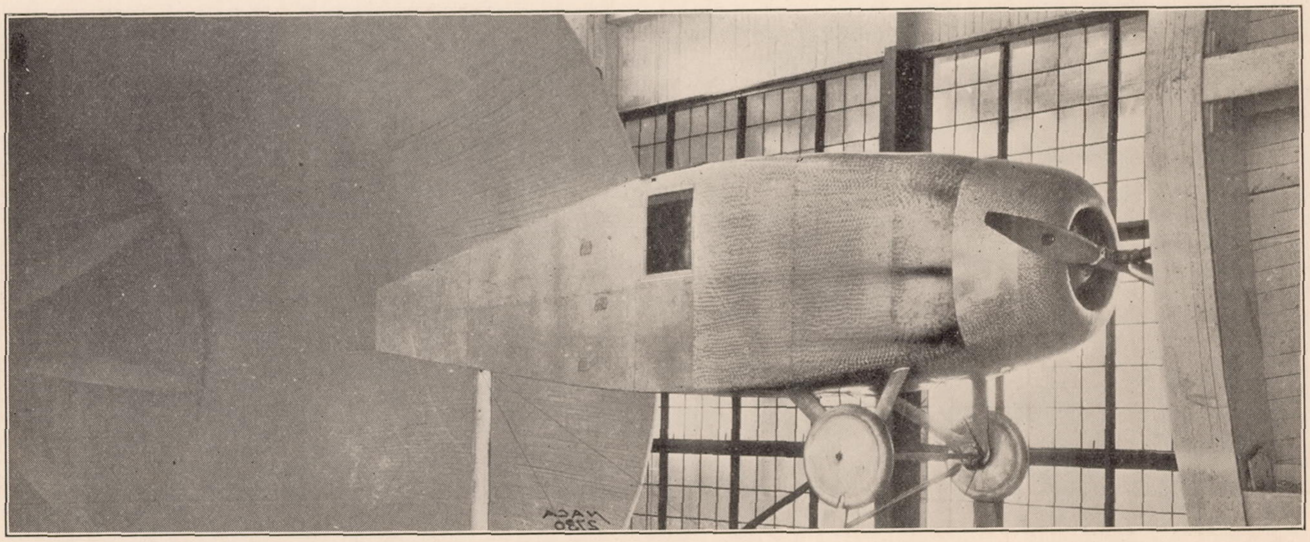

FIGURE 6.—Cabin fuselage with J–5 engine and N.A.C.A. engine cowling.

The test data were converted to the following coefficient forms and plotted against V/nD:

$$\text{Thrust coefficient } C_T = \frac{T_e}{\rho n^2 D^4}$$

$$\text{Power coefficient } C_P = \frac{P}{\rho n^3 D^5}$$

$$\text{Propulsive efficiency } \eta = \frac{T_e V}{P}$$

The significance of the terms in these coefficient forms is as follows:

T_e, effective thrust $T - \Delta D$.
T, thrust of propeller (tension in propeller shaft).
ΔD, change in drag of airplane due to propeller slipstream.
P, input power of engine.
D, propeller diameter.
n, revolutions per unit of time.
V, air speed.
ρ, mass density of air.

The thrust, power, and efficiency curves for the five blade angles were faired, cross-plotted, and replotted and in this way smooth curves for all blade angles from 10° to 28° at 0.75 R were obtained. The C_S charts in reference 1 were prepared from these faired data.

The values of C_T, C_P, η, and C_S corresponding to the charts given in Technical Report No. 350 are given in tables I to XXIV. The use of the tabular values may improve the accuracy in certain parts of the charts and may also be of help to designers in reducing the data to coefficients of another form.

It is possible to obtain propeller thrust by using the C_S propeller charts in reference 1, but the usefulness of these charts for such calculations is impaired by the following existing conditions: (1) In the low-speed (low V/nD) range of propeller operation, which for take-off is of particular interest, the curves on the C_S charts are either entirely missing or so congested as to render them of little practical value. (2) Owing to the fact that C_S involves the factor n which varies with the air speed, an indirect method of some length has generally been used in the past. Recently, however, a direct method of calculating propeller thrust from C_S charts has been evolved (reference 3). This method also suffers from the above-mentioned limitations of the C_S charts although the tables given here will facilitate the calculations to some extent.

DERIVATION OF C_{QS}

If the propeller characteristics are plotted using coefficients in which the propeller revolution speed is not involved, these difficulties may be eliminated. Such a chart is found in the plot of the ratio C_T/C_Q against a "torque speed" coefficient C_{QS} which was developed in the following manner:

Propeller torque Q is expressed by $Q = C_Q \rho n^2 D^5$ from which is obtained the torque coefficient $C_Q = \frac{Q}{\rho n^2 D^5}$. As C_Q is a function of V/nD and as both are nondimensional, any number of other nondimensional torque coefficients may be developed by multiplying C_Q by powers of V/nD. By the use of the proper power of V/nD it is often possible to produce coefficients in which some objectionable variable is eliminated.

If C_Q is multiplied by $(V/nD)^{-2}$ a torque coefficient, which may be designated K, is produced in which the variable n is absent.

$$K = \frac{Q}{\rho n^2 D^5} \times \left(\frac{nD}{V}\right)^2 = \frac{Q}{\rho D^3 V^2}$$

As V is to be an active variable it is desirable to have it in its first power. The coefficient C_{QS}, which provides this feature, is defined by

$$C_{QS} = \frac{1}{\sqrt{K}} = V\sqrt{\frac{\rho D^3}{Q}}$$

Since the torque of an unsupercharged engine is nearly constant throughout the ordinary flight range of full-throttle operation, it is evident that the value of C_{QS} is practically independent of the engine revolution speed in that range.

The diameter D is determined by the method given in reference 1 or by other means and Q, the engine torque, may be calculated from the rated power and speed of the engine by the equation $Q = \frac{\text{hp.} \times 5250}{\text{r.p.m.}}$. Since ρ, D, and Q for a given altitude and diameter are constant $C_{QS} = V \times \text{constant} = kV$.

The coefficients C_{QS} and C_T/C_Q both being single-valued functions of V/nD may be plotted against each other. Now

$$C_T/C_Q = \frac{T_e \rho n^2 D^5}{Q \rho n^2 D^4} = \frac{T_e D}{Q}$$

and, since D and Q remain constant throughout the velocity range, $C_T/C_Q = T_e \times (\text{constant}) = k\ T_e$. It is therefore evident that the propeller thrust for unsupercharged engines may be directly and easily obtained for any velocity from a plot of C_T/C_Q against C_{QS}. The fact that engine torque varies with altitude must of course be considered in making altitude calculations.

Problems involving supercharged engines present complications that can be solved only with a fuller knowledge of the characteristics of the particular engine being used. Moderately supercharged engines with critical[1] altitudes of 5,000 feet or less may, however, be regarded as unsupercharged engines without much loss in the accuracy of thrust calculations.

Engines with critical altitudes over 5,000 feet usually require manifold-pressure limiting devices for protec-

[1] Critical altitude is that altitude to which the rated or maximum allowable sea-level manifold pressure can be maintained with rated altitude engine revolution speed.

tion in sea-level operation. At sea level when such a device is used the manifold pressure remains constant at its limiting value and, since the brake mean effective pressure and torque are dependent mainly upon manifold pressure, they also remain nearly constant. It appears therefore that no modification of the unsupercharged engine method of thrust calculation is necessary except for highly supercharged engines operating at or above critical altitude.

The construction of C_{QS} charts is facilitated by the use of the following relations:

$$\frac{C_T}{C_Q}=\frac{\dfrac{\eta C_P}{V/nD}}{\dfrac{C_P}{2\pi}}=\frac{\eta C_P 2\pi}{VC_P/nD}=\frac{2\pi\eta}{V/nD}$$

and

$$C_{QS}=\frac{V}{nD}\times\sqrt{\frac{1}{C_Q}}=\frac{V}{nD}\sqrt{\frac{2\pi}{C_P}}$$

Propeller-performance charts for each of the six engine-fuselage arrangements were prepared from the data originally obtained for reference 1. These charts, which are given in figures 7 to 12, cover the normal flight and blade-angle range of most present-day airplanes.

Although the primary purpose of the charts is to permit the determination of propeller thrust throughout the flight range, the superimposed lines of constant V/nD enable one to obtain the efficiency and engine revolution speed at any air speed. Although reasonably good at high speeds, the accuracy of the latter determinations becomes increasingly poorer at low speeds and they should not be relied upon below a V/nD of 0.3. Since the curves in the present report and those in reference 1 were independently faired, they cannot be expected to give exactly the same results, even though they were prepared from the same data.

The use of the propeller-performance charts will be illustrated by an example of an airplane with a cowled engine (similar to fig. 6) having a high speed of 180 miles per hour and powered with a radial engine rated at 450 brake horsepower at 2,000 r.p.m.

The propeller selection will be made from reference 1. At sea level,

$$C_S=\frac{0.638\times \text{m.p.h.}}{(\text{hp.})^{1/5}\times(\text{r.p.m.})^{2/5}}$$

At high speed for this airplane,

$$C_S=\frac{0.638\times 180}{3.4\times 20.95}=1.61$$

If a propeller giving maximum speed is selected from figure 14 of reference 1, the value of V/nD at high speed is found to be 0.91, the blade angle β to be 25°, and the propulsive efficiency η to be 0.845.

The diameter D is then $\dfrac{88\times 180}{2{,}000\times 0.91}=8.7$ feet and the engine torque of the propeller shaft is

$$\frac{\text{hp.}\times 5{,}250}{\text{r.p.m}}=\frac{450\times 5{,}250}{2{,}000}=1{,}180 \text{ pound-feet}$$

$$C_{QS}=V\sqrt{\frac{\rho D^5}{Q}}=V\sqrt{\frac{0.002378\times 8.7^5}{1{,}180}}=0.0364\ V$$

(V in feet per second) or 0.0534 V (V in miles per hour). $Q/D=1{,}180/8.7=135.7$ pounds.

It is convenient to put the remaining calculations in tabular form.

PROPELLER THRUST CALCULATION

V (m.p.h.)	0	20	40	60	80	100	120	140	160	180
C_{QS}	0	1.07	2.13	3.20	4.27	5.34	6.40	7.47	8.54	9.60
C_T/C_Q	7.60	7.75	7.88	7.90	7.83	7.60	7.14	6.63	6.19	5.82
T_e (lb.)	1,030	1,050	1,069	1,070	1,060	1,030	967	898	838	789
t.hp.$_a$	0	56	114	171	226	274	310	335	358	378

The values of C_T/C_Q in the table were obtained from figure 12. The thrust T_e equals $C_T/C_Q\times Q/D=TD/Q\times Q/D$ and the thrust horsepower available (t.hp.$_a$) equals $T_e\times$(m.p.h.)/375.

The efficiency at 180 miles per hour is $378/450=0.0840$, which checks with the value (0.845) obtained from reference 1. If the efficiency and engine revolution speed at the climbing air speed (100 miles per hour) be desired, the procedure for finding them is as follows: The V/nD at 100 miles per hour is about 0.565 (from fig. 12) and the efficiency is equal to

$$\frac{C_T}{C_Q}\times\frac{V}{nD}\times\frac{1}{2\pi}$$

which for this example equals $(7.60\times 5.65)/2\pi=0.68$.

The engine speed at 100 miles per hour is equal to

$$\frac{V\times 88}{\dfrac{V}{nD}D}=\frac{100\times 88}{0.565\times 8.7}=1{,}790 \text{ r.p.m.}$$

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., *December 4, 1933.*

REFERENCES

1. Weick, Fred E.: Working Charts for the Selection of Aluminum Alloy Propellers of a Standard Form to Operate with Various Aircraft Engines and Bodies. T.R. No. 350, N.A.C.A., 1930.
2. Weick, Fred E., and Wood, Donald H.: The Twenty-Foot Propeller Research Tunnel of the National Advisory Committee for Aeronautics. T.R. No. 300, N.A.C.A., 1928.
3. Ober, Shatswell: Estimation of the Variation of Thrust Horsepower with Air Speed. T.N. No. 446, N.A.C.A., 1933.

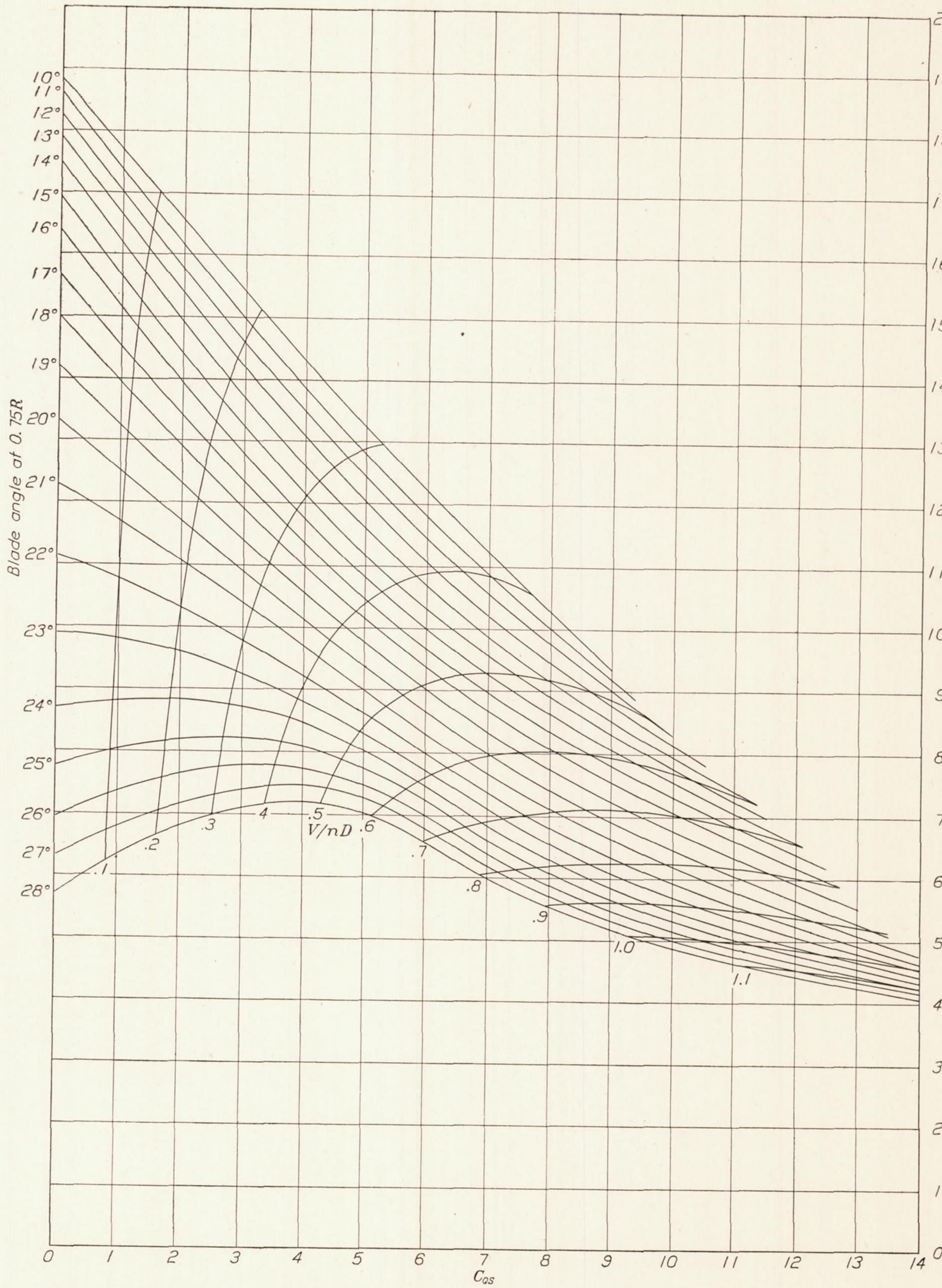

FIGURE 7.—Propeller-performance chart for an open-cockpit fuselage with a 400-horsepower Curtiss D-12 engine. C_{QS} is proportional to V; C_T/C_Q is proportional to T.

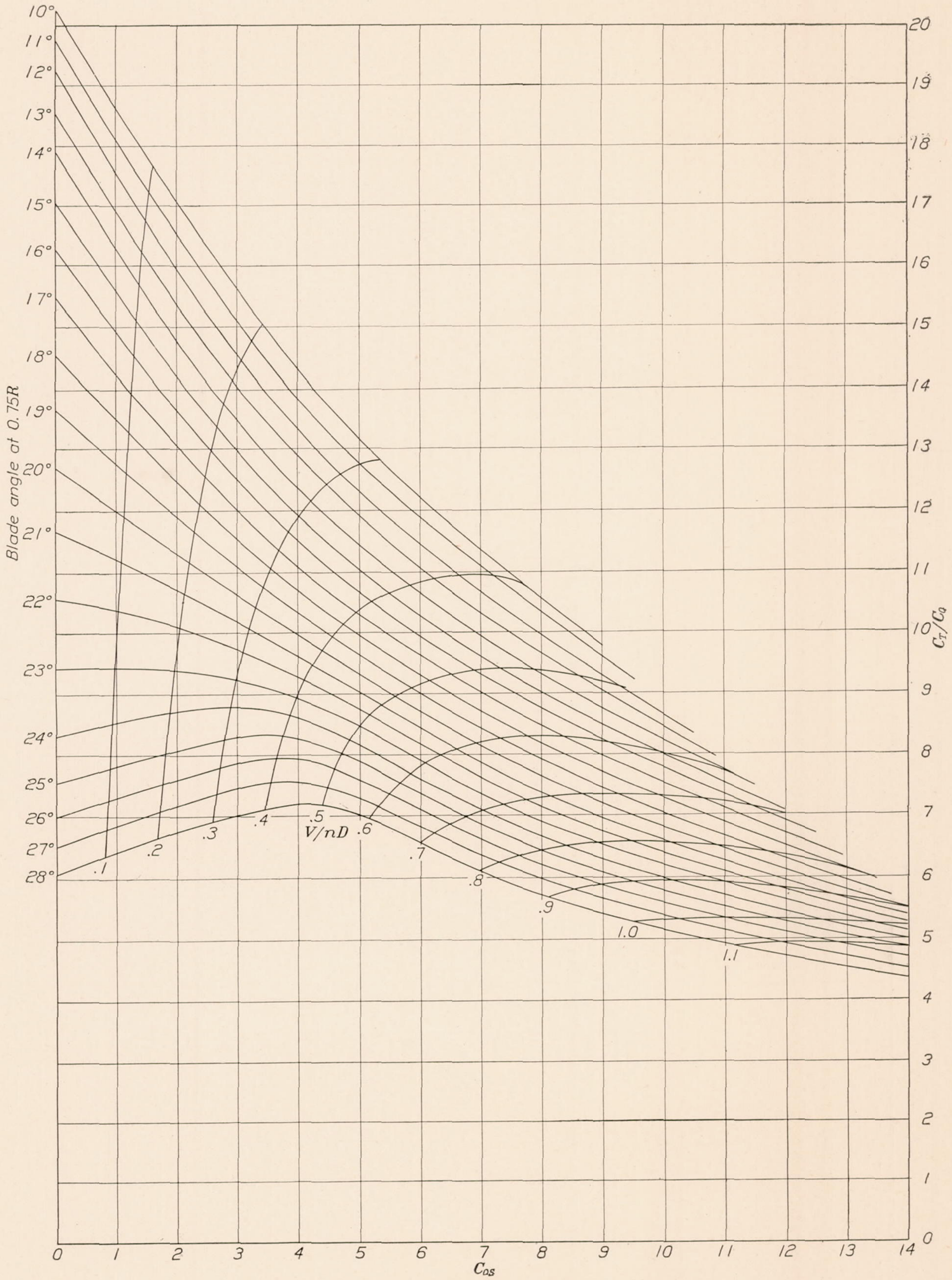

FIGURE 8.—Propeller-performance chart for a complete VE-7 airplane with 180-horsepower Wright E-2 water-cooled engine with nose radiator. C_{QS} is proportional to V; C_T/C_Q is proportional to T_e.

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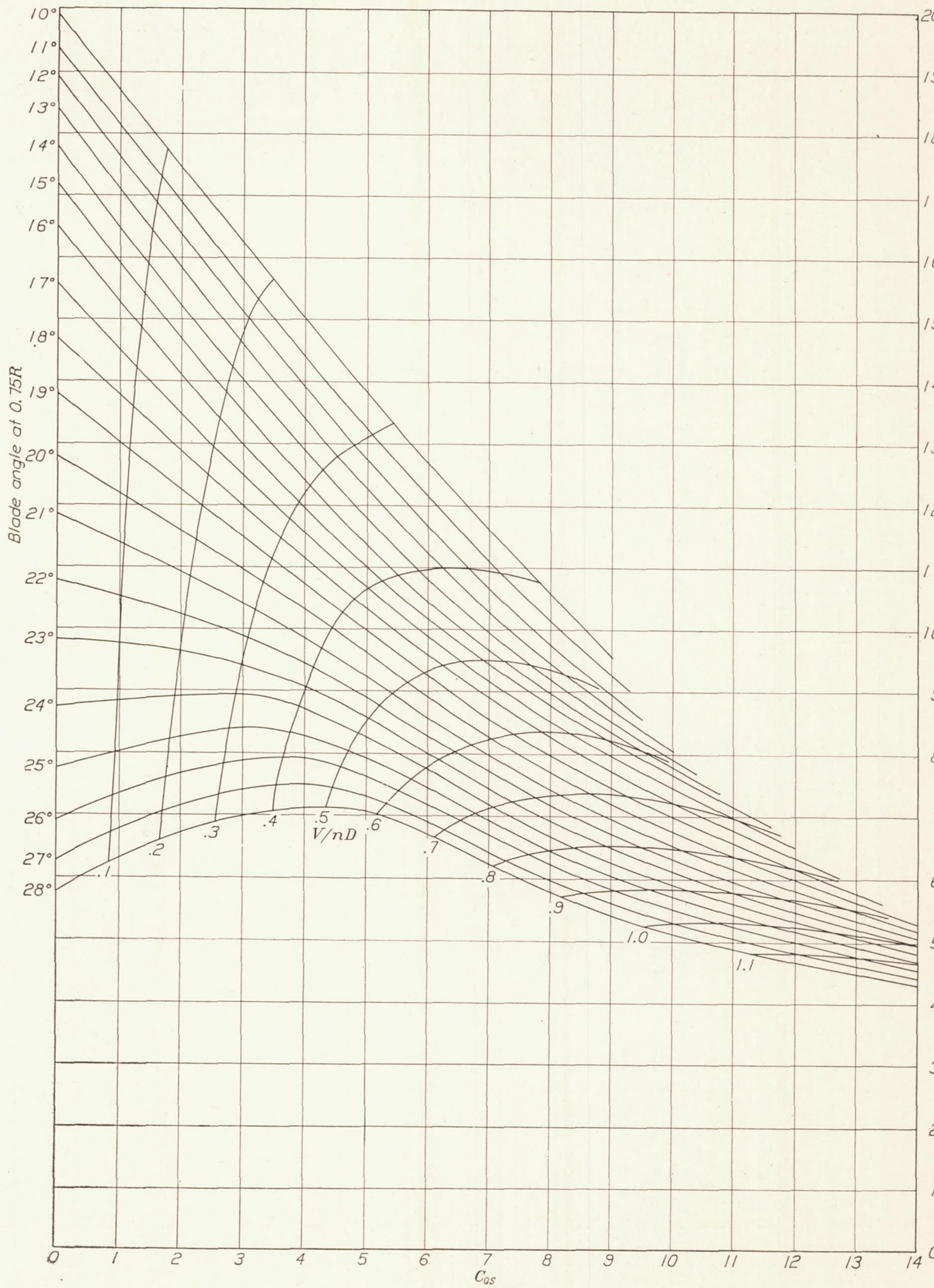


FIGURE 9.—Propeller-performance chart for an open-cockpit fuselage with Wright Whirlwind J-5 9-cylinder engine. C_{QS} is proportional to V; C_T/C_Q is proportional to T_e

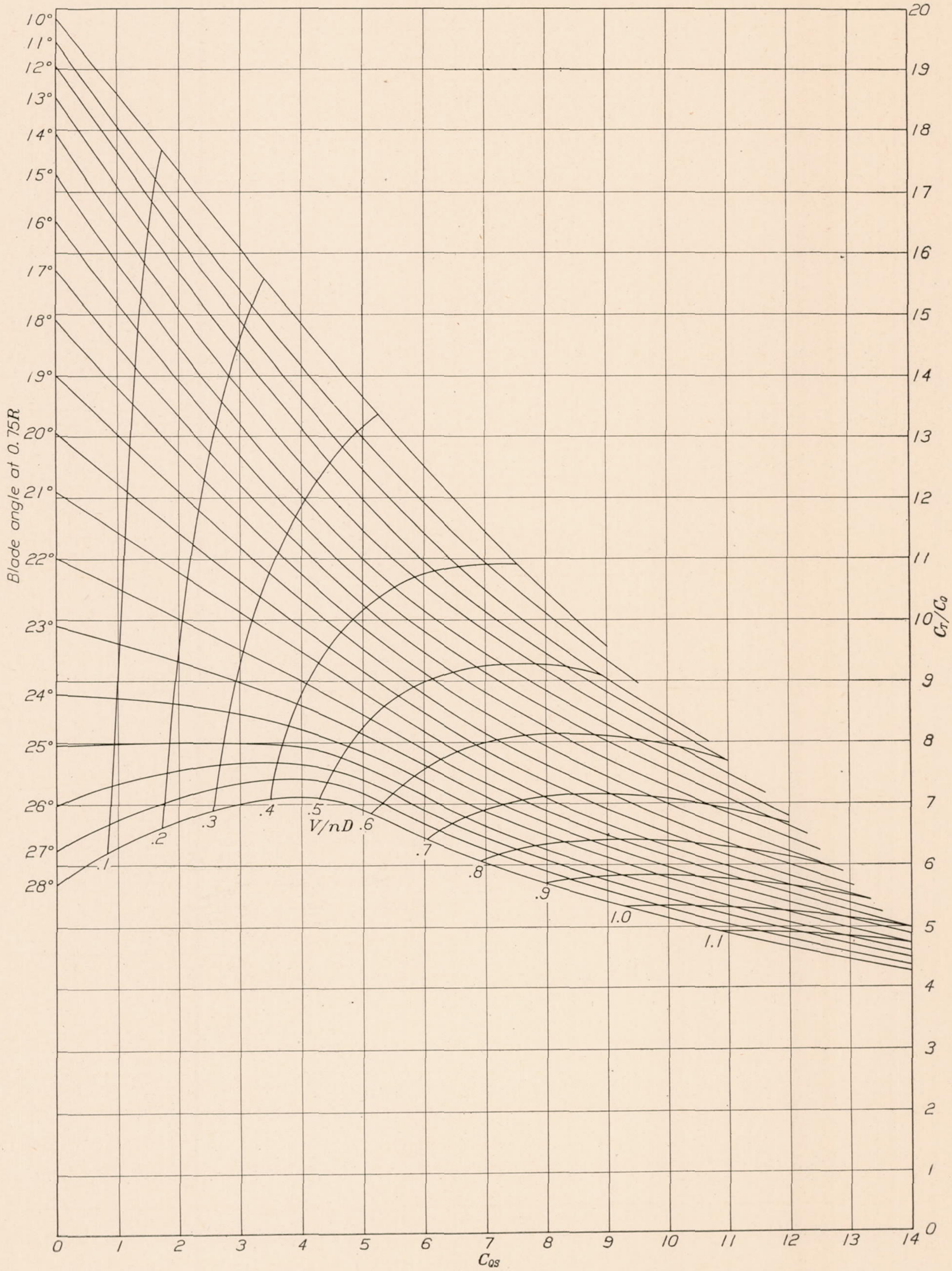


FIGURE 10.—Propeller-performance chart for a cabin monoplane with J-5 engine. C_{QS} is proportional to V; C_T/C_Q is proportional to T_s.

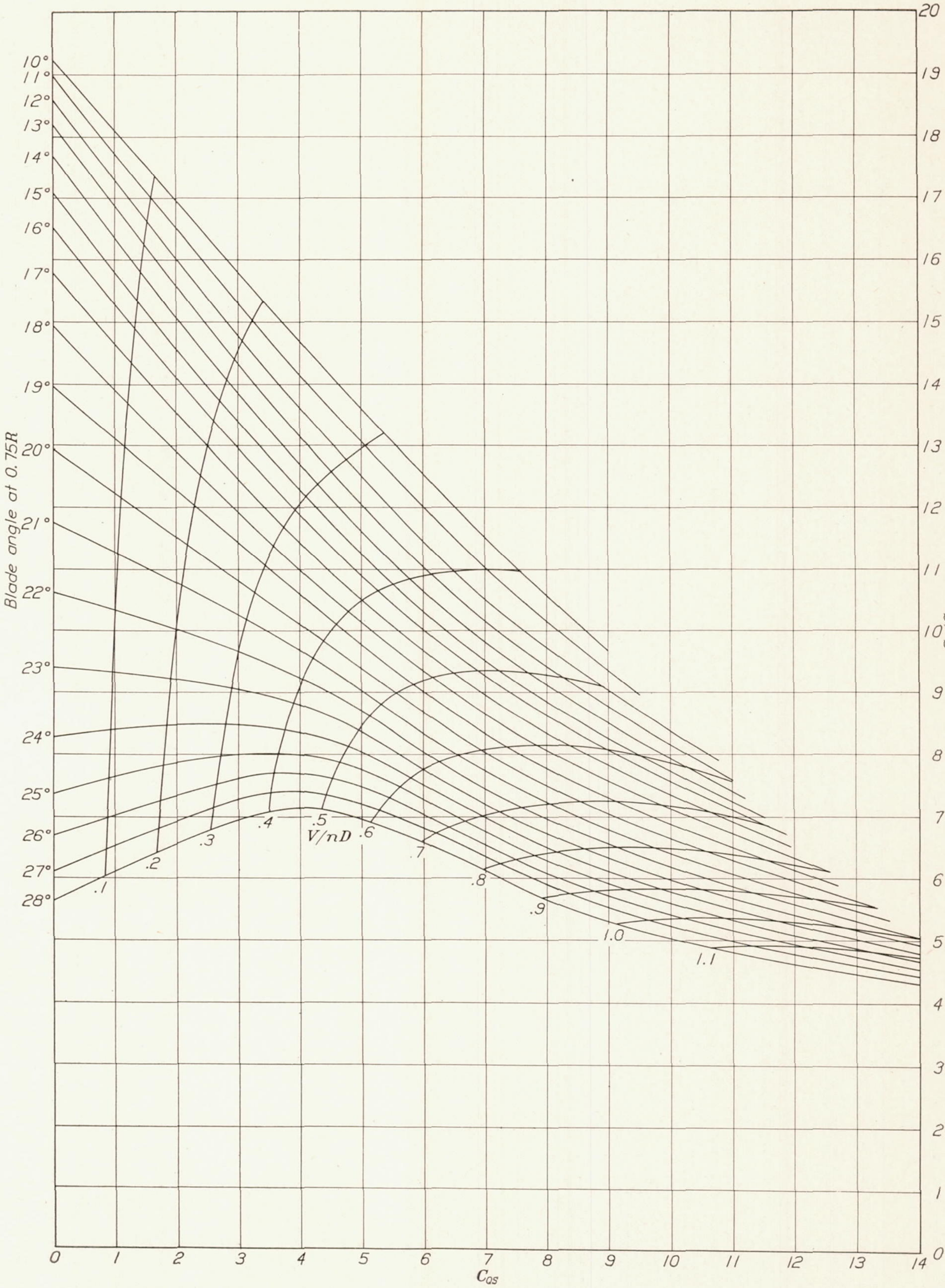


FIGURE 11.—Propeller-performance chart for a cabin fuselage with J-5 engine. C_{QS} is proportional to V; C_T/C_Q is proportional to T_e.

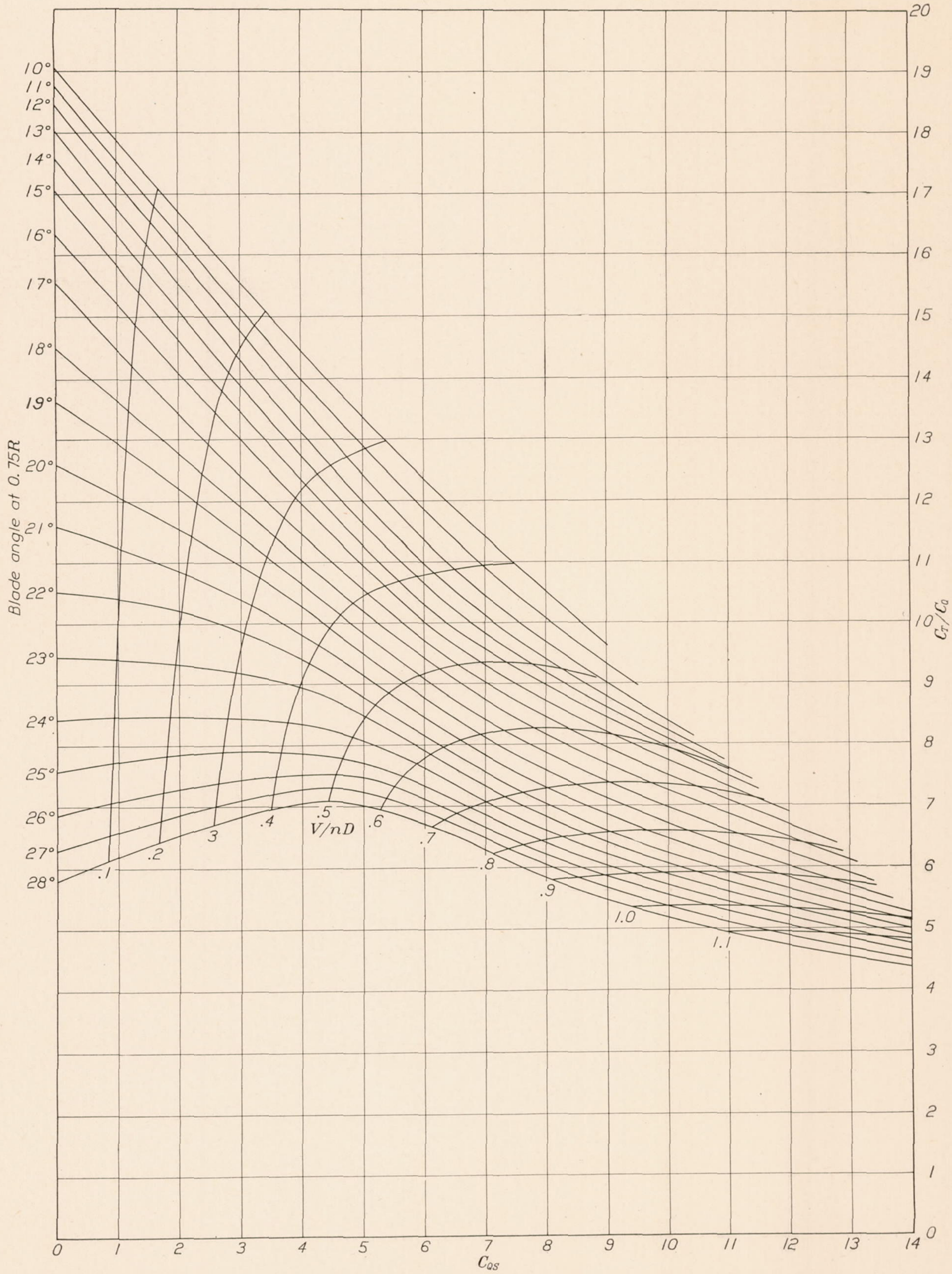


FIGURE 12.—Propeller-performance chart for a cabin fuselage with J-5 engine and N.A.C.A. engine cowling. C_{QS} is proportional to V; C_T/C_Q is proportional to T_e.

TABLE I

OPEN-COCKPIT FUSELAGE WITH D–12 ENGINE

VALUES OF C_T

(See fig. 1)

Blade angle at 0.75 R	$\frac{V}{nD}$													
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4
°														
10	0.0648	0.0540	0.0422	0.0290	0.0148									
11	.0689	.0593	.0476	.0350	.0206									
12	.0733	.0638	.0528	.0408	.0263	0.0122								
13	.0773	.0686	.0578	.0463	.0319	.0179								
14	.0813	.0727	.0627	.0514	.0376	.0237								
15	.0849	.0767	.0675	.0565	.0432	.0294	0.0165							
16	.0880	.0802	.0716	.0611	.0486	.0352	.0214							
17	.0912	.0838	.0758	.0658	.0539	.0410	.0275	0.0146						
18	.0942	.0871	.0797	.0703	.0593	.0467	.0337	.0209						
19	.0970	.0910	.0836	.0747	.0646	.0524	.0400	.0272	0.0150					
20	.0987	.0943	.0875	.0792	.0698	.0580	.0462	.0336	.0208					
21	.1010	.0971	.0910	.0837	.0750	.0638	.0521	.0395	.0266	0.0143				
22	.1017	.0987	.0939	.0876	.0798	.0694	.0577	.0453	.0327	.0204				
23	.1016	.1001	.0962	.0909	.0843	.0747	.0636	.0514	.0390	.0265	0.0141			
24	.0998	.0993	.0971	.0936	.0883	.0796	.0694	.0573	.0453	.0329	.0204			
25	.0997	.0993	.0975	.0959	.0912	.0839	.0753	.0633	.0517	.0395	.0270	0.0139		
26	.0987	.0991	.0979	.0970	.0936	.0878	.0809	.0692	.0580	.0462	.0336	.0200		
27	.0993	.0986	.0980	.0975	.0950	.0912	.0855	.0752	.0643	.0527	.0403	.0263	0.0132	
28	.1002	.0991	.0992	.0975	.0960	.0938	.0890	.0811	.0707	.0592	.0468	.0329	.0192	0.0097

TABLE II

OPEN-COCKPIT FUSELAGE WITH D–12 ENGINE

VALUES OF C_P

Blade angle at 0.75 R	$\frac{V}{nD}$													
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4
°														
10	0.0240	0.0224	0.0205	0.0172	0.0121	0.0076								
11	.0260	.0250	.0233	.0203	.0155	.0105	0.0040							
12	.0281	.0275	.0261	.0235	.0188	.0135	.0066							
13	.0302	.0302	.0290	.0266	.0221	.0166	.0096	0.0028						
14	.0325	.0328	.0320	.0299	.0256	.0200	.0128	.0057						
15	.0348	.0355	.0351	.0332	.0292	.0236	.0165	.0092	0.0022					
16	.0373	.0382	.0380	.0365	.0329	.0275	.0206	.0132	.0064					
17	.0400	.0410	.0411	.0399	.0367	.0318	.0253	.0178	.0108					
18	.0430	.0440	.0443	.0433	.0408	.0364	.0303	.0229	.0155	0.0062				
19	.0464	.0474	.0478	.0470	.0450	.0411	.0355	.0283	.0205	.0114				
20	.0501	.0511	.0516	.0511	.0494	.0461	.0409	.0340	.0258	.0169	0.0063			
21	.0546	.0555	.0558	.0555	.0540	.0513	.0463	.0397	.0316	.0227	.0123			
22	.0595	.0602	.0602	.0600	.0587	.0564	.0517	.0456	.0379	.0290	.0186	0.0069		
23	.0651	.0654	.0650	.0646	.0634	.0615	.0575	.0518	.0445	.0356	.0252	.0135		
24	.0713	.0707	.0697	.0691	.0680	.0664	.0635	.0581	.0513	.0426	.0323	.0206	0.0085	
25	.0785	.0764	.0746	.0736	.0723	.0711	.0696	.0645	.0582	.0499	.0397	.0282	.0165	0.0031
26	.0851	.0822	.0796	.0779	.0765	.0757	.0756	.0710	.0653	.0575	.0474	.0361	.0232	.0106
27	.0930	.0880	.0845	.0821	.0804	.0800	.0808	.0776	.0725	.0652	.0554	.0445	.0313	.0186
28	.1012	.0939	.0894	.0863	.0842	.0839	.0852	.0843	.0800	.0731	.0636	.0531	.0401	.0271

TABLE III

OPEN-COCKPIT FUSELAGE WITH D–12 ENGINE

VALUES OF η

Blade angle at 0.75 R	$\frac{V}{nD}$													
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4
°														
10	0.270	0.483	0.617	0.675	0.610									
11	.265	.474	.613	.689	.664									
12	.261	.464	.607	.695	.699									
13	.256	.454	.598	.696	.722	0.647								
14	.250	.443	.588	.688	.735	.710								
15	.244	.432	.577	.680	.740	.747	0.701							
16	.236	.420	.565	.670	.739	.768	.726							
17	.228	.409	.553	.660	.735	.773	.760	0.654						
18	.219	.396	.540	.649	.727	.770	.779	.729						
19	.209	.384	.525	.636	.718	.765	.788	.770	0.660					
20	.197	.369	.509	.620	.706	.755	.790	.790	.726					
21	.185	.350	.489	.603	.694	.746	.788	.796	.759	0.629				
22	.171	.328	.468	.584	.680	.738	.781	.795	.777	.702				
23	.156	.306	.444	.563	.665	.729	.774	.794	.789	.745	0.616			
24	.140	.281	.418	.542	.649	.719	.765	.789	.795	.772	.696			
25	.127	.260	.392	.521	.631	.708	.757	.785	.799	.791	.747	0.590		
26	.116	.241	.369	.498	.612	.696	.749	.780	.799	.803	.780	.664		
27	.107	.224	.348	.475	.591	.684	.741	.775	.798	.809	.800	.710	0.550	
28	.099	.211	.333	.452	.570	.671	.731	.770	.795	.810	.810	.743	.621	0.500

TABLE IV

OPEN-COCKPIT FUSELAGE WITH D-12 ENGINE

VALUES OF C_S

Blade angle at 0.75 R	$\frac{V}{nD}$													
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4
°														
10	0.211	0.428	0.652	0.900	1.204	1.590								
11	.208	.420	.632	.871	1.152	1.499								
12	.205	.410	.620	.848	1.110	1.422								
13	.201	.400	.608	.828	1.077	1.362	1.797							
14	.200	.391	.596	.808	1.043	1.313	1.688							
15	.198	.387	.589	.790	1.017	1.270	1.600	2.086						
16	.192	.380	.579	.773	.990	1.230	1.526	1.902						
17	.190	.375	.570	.760	.969	1.197	1.463	1.781	2.350					
18	.189	.370	.561	.748	.949	1.164	1.412	1.693	2.132					
19	.184	.363	.551	.738	.930	1.137	1.370	1.629	1.979	2.522				
20	.180	.360	.543	.722	.912	1.110	1.330	1.572	1.868	2.288				
21	.179	.353	.537	.711	.900	1.082	1.299	1.526	1.786	2.138	2.680			
22	.176	.350	.529	.700	.885	1.061	1.270	1.481	1.723	2.030	2.460			
23	.172	.343	.520	.690	.870	1.040	1.246	1.445	1.676	1.948	2.305	2.842		
24	.170	.340	.512	.680	.851	1.023	1.221	1.411	1.632	1.880	2.188	2.619		
25	.168	.333	.508	.670	.848	1.010	1.200	1.383	1.596	1.820	2.093	2.455	2.980	
26	.162	.330	.500	.661	.838	1.001	1.180	1.360	1.560	1.770	2.020	2.330	2.742	
27	.160	.325	.491	.657	.828	.994	1.165	1.340	1.530	1.728	1.960	2.231	2.581	3.110
28	.158	.320	.487	.650	.819	.990	1.151	1.321	1.505	1.690	1.910	2.159	2.470	2.875

TABLE V

"VE-7" AIRPLANE

VALUES OF C_T

(See fig. 2)

Blade angle at 0.75 R	$\frac{V}{nD}$											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
°												
10	0.0646	0.0528	0.0409	0.0293	0.0167							
11	.0712	.0581	.0467	.0349	.0227							
12	.0761	.0633	.0520	.0400	.0278	0.0141						
13	.0802	.0681	.0571	.0450	.0326	.0195						
14	.0845	.0726	.0621	.0501	.0380	.0250	0.0133					
15	.0871	.0766	.0674	.0555	.0436	.0309	.0188					
16	.0903	.0806	.0721	.0609	.0494	.0369	.0244					
17	.0930	.0846	.0762	.0659	.0554	.0431	.0301	0.0169				
18	.0943	.0873	.0804	.0709	.0611	.0492	.0362	.0230	0.0108			
19	.0956	.0904	.0840	.0759	.0666	.0554	.0418	.0295	.0164			
20	.0973	.0927	.0880	.0805	.0718	.0611	.0484	.0353	.0223			
21	.0975	.0944	.0910	.0844	.0764	.0667	.0546	.0415	.0284	0.0162		
22	.0970	.0962	.0930	.0882	.0809	.0719	.0603	.0476	.0346	.0221		
23	.0950	.0971	.0953	.0912	.0845	.0768	.0657	.0536	.0407	.0281	0.0158	
24	.0929	.0952	.0968	.0935	.0876	.0809	.0710	.0592	.0471	.0341	.0216	
25	.0930	.0948	.0972	.0954	.0906	.0849	.0757	.0649	.0529	.0400	.0277	
26	.0941	.0952	.0967	.0967	.0926	.0879	.0804	.0703	.0587	.0460	.0341	
27	.0970	.0956	.0963	.0965	.0939	.0907	.0849	.0755	.0642	.0521	.0406	
28	.1005	.0974	.0960	.0961	.0948	.0928	.0888	.0802	.0694	.0582	.0470	0.0357

TABLE VI

"VE-7" AIRPLANE

VALUES OF C_P

Blade angle at 0.75 R	$\frac{V}{nD}$											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
°												
10	0.0230	0.0220	0.0201	0.0171	0.0130	0.0077	0.0000					
11	.0260	.0247	.0230	.0200	.0160	.0103	.0030					
12	.0285	.0275	.0259	.0230	.0190	.0132	.0062					
13	.0311	.0304	.0289	.0261	.0220	.0165	.0096	0.0000				
14	.0338	.0332	.0320	.0294	.0254	.0200	.0133	.0044				
15	.0363	.0362	.0354	.0330	.0291	.0240	.0173	.0090				
16	.0391	.0392	.0387	.0366	.0322	.0282	.0216	.0136	0.0044			
17	.0419	.0424	.0421	.0403	.0374	.0327	.0261	.0185	.0097	0.0008		
18	.0447	.0456	.0456	.0442	.0418	.0373	.0310	.0236	.0150	.0059		
19	.0478	.0490	.0492	.0481	.0461	.0421	.0361	.0288	.0202	.0110	0.0030	
20	.0512	.0525	.0530	.0520	.0504	.0469	.0413	.0341	.0257	.0163	.0076	0.0010
21	.0548	.0562	.0569	.0560	.0546	.0518	.0468	.0396	.0313	.0219	.0125	.0043
22	.0588	.0603	.0609	.0601	.0588	.0567	.0522	.0453	.0371	.0277	.0177	.0083
23	.0633	.0645	.0650	.0640	.0630	.0615	.0576	.0511	.0430	.0338	.0235	.0129
24	.0688	.0690	.0693	.0680	.0670	.0662	.0631	.0570	.0493	.0402	.0297	.0181
25	.0750	.0741	.0738	.0720	.0711	.0708	.0685	.0632	.0557	.0468	.0363	.0244
26	.0818	.0797	.0782	.0761	.0752	.0753	.0740	.0694	.0624	.0539	.0437	.0318
27	.0898	.0857	.0828	.0801	.0793	.0798	.0794	.0758	.0694	.0614	.0518	.0403
28	.0995	.0923	.0873	.0841	.0832	.0842	.0848	.0822	.0766	.0693	.0603	.0500

TABLE VII

"VE-7" AIRPLANE

VALUES OF η

Blade angle at 0.75 R	$\frac{V}{nD}$											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
°												
10	0.281	0.480	0.610	0.686	0.641	----	----	----	----	----	----	----
11	.274	.470	.609	.699	.709	----	----	----	----	----	----	----
12	.267	.460	.602	.696	732	0.639	----	----	----	----	----	----
13	.258	.448	.593	.690	.742	.707	----	----	----	----	----	----
14	.250	.437	.582	.681	.749	.749	0.700	----	----	----	----	----
15	.240	.423	.571	.673	.749	.772	.761	----	----	----	----	----
16	.231	.411	.559	.665	.744	.786	.791	----	----	----	----	----
17	.222	.399	.543	.654	.740	.791	.808	0.732	----	----	----	----
18	.211	.383	.529	.642	.731	.791	.817	.781	0.649	----	----	----
19	.200	.369	.512	.631	.722	.789	.811	.820	.730	----	----	----
20	.190	.353	.498	.619	.712	.781	.820	.829	.782	----	----	----
21	.178	.336	.480	.603	.700	.772	.816	.838	.816	0.740	----	----
22	.165	.319	.460	.587	.688	.761	.809	.840	.840	.797	----	----
23	.150	.301	.440	.570	.671	.749	.799	.839	.852	.830	0.740	----
24	.135	.276	.419	.550	.654	.733	.788	.831	.859	.848	.802	----
25	.124	.255	.395	.530	.637	.719	.774	.821	.855	.854	.840	----
26	.115	.239	.371	.508	.616	.700	.761	.810	.846	.853	.859	----
27	.108	.223	.349	.482	.592	.682	.749	.797	.832	.849	.862	----
28	.101	.211	.330	.457	.570	.661	.733	.780	.815	.840	.858	0.857

TABLE VIII

"VE-7" AIRPLANE

VALUES OF C_S

Blade angle at 0.75 R	$\frac{V}{nD}$											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
°												
10	0.212	0.431	0.660	0.910	1.190	----	----	----	----	----	----	----
11	.207	.420	.640	.879	1.146	1.492	----	----	----	----	----	----
12	.203	.411	.621	.852	1.108	1.429	----	----	----	----	----	----
13	.199	.402	.609	.829	1.071	1.370	----	----	----	----	----	----
14	.197	.393	.594	.809	1.040	1.315	1.650	----	----	----	----	----
15	.194	.388	.585	.790	1.012	1.269	1.580	2.020	----	----	----	----
16	.191	.380	.576	.773	.988	1.228	1.514	1.901	----	----	----	----
17	.189	.376	.566	.759	.962	1.190	1.455	1.790	----	----	----	----
18	.186	.370	.557	.743	.942	1.158	1.402	1.710	2.080	----	----	----
19	.184	.362	.548	.731	.923	1.130	1.360	1.638	1.963	2.430	----	----
20	.181	.360	.540	.720	.907	1.105	1.322	1.575	1.870	2.291	----	----
21	.179	.354	.532	.710	.892	1.081	1.292	1.526	1.793	2.170	----	----
22	.177	.350	.528	.700	.880	1.062	1.270	1.482	1.736	2.065	2.460	----
23	.174	.348	.520	.691	.869	1.047	1.246	1.450	1.686	1.976	2.326	2.861
24	.171	.341	.511	.685	.858	1.030	1.226	1.419	1.641	1.901	2.219	2.670
25	.168	.338	.508	.678	.848	1.018	1.204	1.390	1.602	1.840	2.128	2.510
26	.165	.332	.500	.670	.838	1.005	1.184	1.368	1.570	1.790	2.051	2.332
27	.162	.330	.492	.662	.829	.992	1.162	1.341	1.538	1.746	1.983	2.275
28	.159	.327	.488	.659	.819	.982	1.143	1.320	1.507	1.706	1.923	2.181

TABLE IX

OPEN-COCKPIT FUSELAGE WITH J-5 ENGINE

VALUES OF C_T

(See fig. 3)

Blade angle at 0.75 R	$\frac{V}{nD}$											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
°												
10	0.0606	0.0526	0.0419	0.0288	0.0174	----	----	----	----	----	----	----
11	.0662	.0578	.0472	.0348	.0224	----	----	----	----	----	----	----
12	.0718	.0630	.0523	.0408	.0279	0.0133	----	----	----	----	----	----
13	.0768	.0675	.0572	.0466	.0331	.0196	----	----	----	----	----	----
14	.0813	.0719	.0621	.0522	.0385	.0258	----	----	----	----	----	----
15	.0849	.0757	.0670	.0579	.0442	.0321	0.0169	----	----	----	----	----
16	.0871	.0792	.0718	.0631	.0498	.0380	.0233	----	----	----	----	----
17	.0884	.0822	.0759	.0678	.0554	.0436	.0296	0.0161	----	----	----	----
18	.0899	.0852	.0802	.0727	.0611	.0491	.0358	.0222	----	----	----	----
19	.0908	.0877	.0839	.0769	.0666	.0544	.0418	.0319	0.0161	----	----	----
20	.0919	.0899	.0870	.0807	.0713	.0597	.0477	.0344	.0222	----	----	----
21	.0936	.0920	.0896	.0842	.0760	.0648	.0538	.0405	.0284	0.0159	----	----
22	.0948	.0934	.0915	.0870	.0802	.0701	.0597	.0467	.0345	.0219	----	----
23	.0958	.0952	.0934	.0896	.0840	.0749	.0654	.0528	.0403	.0280	0.0150	----
24	.0959	.0955	.0955	.0915	.0871	.0795	.0705	.0587	.0461	.0342	.0214	----
25	.0950	.0956	.0956	.0931	.0896	.0834	.0756	.0646	.0520	.0405	.0281	0.0154
26	.0952	.0956	.0957	.0938	.0917	.0873	.0804	.0701	.0581	.0467	.0345	.0220
27	.0963	.0959	.0962	.0949	.0932	.0908	.0850	.0757	.0642	.0528	.0409	.0288
28	.0969	.0961	.0955	.0948	.0945	.0938	.0891	.0809	.0702	.0587	.0474	.0356

TABLE X

OPEN-COCKPIT FUSELAGE WITH J-5 ENGINE

VALUES OF C_P

Blade angle at 0.75 R	$\frac{V}{nD}$											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
°												
10	0.0215	0.0210	0.0196	0.0167	0.0128	0.0069	------	------	------	------	------	------
11	.0240	.0236	.0225	.0201	.0162	.0105	0.0010	------	------	------	------	------
12	.0267	.0263	.0253	.0235	.0197	.0140	.0050	------	------	------	------	------
13	.0293	.0289	.0282	.0268	.0230	.0176	.0091	0.0008	------	------	------	------
14	.0320	.0316	.0311	.0301	.0264	.0212	.0133	.0051	------	------	------	------
15	.0345	.0344	.0342	.0335	.0299	.0250	.0175	.0096	------	------	------	------
16	.0369	.0372	.0374	.0369	.0335	.0289	.0220	.0142	0.0045	------	------	------
17	.0391	.0399	.0405	.0401	.0372	.0328	.0264	.0189	.0099	------	------	------
18	.0416	.0428	.0439	.0437	.0412	.0369	.0310	.0237	.0155	0.0056	------	------
19	.0443	.0459	.0473	.0472	.0451	.0412	.0357	.0287	.0210	.0113	------	------
20	.0476	.0494	.0508	.0507	.0492	.0457	.0406	.0339	.0265	.0171	0.0035	------
21	.0517	.0533	.0545	.0544	.0533	.0502	.0459	.0394	.0321	.0228	.0098	------
22	.0564	.0575	.0583	.0582	.0574	.0551	.0513	.0451	.0379	.0287	.0164	0.0044
23	.0618	.0622	.0623	.0621	.0616	.0599	.0569	.0510	.0437	.0348	.0233	.0111
24	.0680	.0675	.0668	.0663	.0658	.0647	.0623	.0571	.0498	.0413	.0305	.0183
25	.0748	.0730	.0715	.0705	.0700	.0696	.0678	.0632	.0563	.0482	.0380	.0259
26	.0821	.0790	.0766	.9750	.0744	.0744	.0732	.0694	.0631	.0555	.0456	.0338
27	.0900	.0852	.0818	.0796	.0787	.0791	.0787	.0758	.0701	.0629	.0534	.0420
28	.0979	.0915	.0871	.0841	.0830	.0839	.0841	.0820	.0771	.0704	.0614	.0506

TABLE XI

OPEN-COCKPIT FUSELAGE WITH J-5 ENGINE

VALUES OF η

Blade angle at 0.75 R	$\frac{V}{nD}$											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
°												
10	0.282	0.501	0.641	0.690	0.678	------	------	------	------	------	------	------
11	.276	.490	.630	.692	.692	------	------	------	------	------	------	------
12	.269	.479	.620	.695	.707	0.571	------	------	------	------	------	------
13	.262	.467	.609	.695	.720	.670	------	------	------	------	------	------
14	.254	.455	.599	.694	.730	.731	------	------	------	------	------	------
15	.245	.440	.588	.691	.739	.770	0.676	------	------	------	------	------
16	.236	.426	.576	.684	.744	.789	.742	------	------	------	------	------
17	.226	.412	.562	.676	.744	.798	.785	0.681	------	------	------	------
18	.216	.398	.548	.665	.741	.798	.809	.749	------	------	------	------
19	.205	.382	.532	.652	.738	.793	.819	.779	0.689	------	------	------
20	.193	.364	.514	.637	.725	.784	.822	.811	.755	------	------	------
21	.181	.345	.493	.619	.713	.774	.821	.823	.796	0.699	------	------
22	.168	.325	.471	.598	.699	.763	.815	.829	.819	.763	------	------
23	.155	.306	.450	.577	.682	.750	.804	.828	.830	.805	0.707	------
24	.141	.283	.429	.552	.662	.737	.792	.823	.833	.829	.772	------
25	.127	.262	.401	.528	.640	.719	.781	.818	.831	.840	.812	0.713
26	.116	.242	.375	.500	.616	.704	.769	.808	.829	.842	.833	.782
27	.107	.225	.353	.477	.592	.689	.756	.799	.824	.840	.843	.823
28	.099	.210	.329	.451	.569	.671	.742	.789	.820	.834	.850	.844

TABLE XII

OPEN-COCKPIT FUSELAGE WITH J-5 ENGINE

VALUES OF C_S

Blade angle at 0.75 R	$\frac{V}{nD}$											
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2
°												
10	0.210	0.428	0.652	0.890	1.174	1.630	------	------	------	------	------	------
11	.208	.420	.640	.869	1.131	1.500	------	------	------	------	------	------
12	.204	.411	.627	.849	1.098	1.412	------	------	------	------	------	------
13	.200	.404	.613	.829	1.080	1.350	1.760	------	------	------	------	------
14	.199	.398	.600	.810	1.037	1.300	1.637	------	------	------	------	------
15	.197	.390	.590	.792	1.010	1.252	1.562	2.015	------	------	------	------
16	.192	.384	.580	.778	.985	1.213	1.505	1.889	------	------	------	------
17	.190	.378	.570	.764	.961	1.182	1.453	1.790	2.285	------	------	------
18	.189	.372	.561	.750	.941	1.158	1.407	1.705	2.086	------	------	------
19	.188	.369	.551	.740	.924	1.133	1.364	1.632	1.969	2.500	------	------
20	.184	.361	.542	.728	.910	1.110	1.328	1.572	1.862	2.272	------	------
21	.180	.358	.533	.718	.892	1.090	1.292	1.523	1.795	2.152	------	------
22	.179	.351	.528	.707	.881	1.070	1.265	1.485	1.736	2.048	2.487	------
23	.178	.347	.520	.697	.870	1.052	1.240	1.450	1.684	1.961	2.328	2.886
24	.172	.340	.512	.688	.859	1.040	1.220	1.420	1.640	1.892	2.206	2.670
25	.169	.332	.508	.680	.850	1.026	1.201	1.392	1.600	1.832	2.130	2.586
26	.162	.329	.500	.671	.840	1.012	1.188	1.367	1.565	1.783	2.045	2.382
27	.160	.322	.492	.662	.831	1.000	1.171	1.341	1.531	1.740	1.980	2.273
28	.158	.318	.489	.655	.822	.988	1.159	1.318	1.498	1.696	1.926	2.172

TABLE XIII

CABIN MONPOLANE WITH J-5 ENGINE

VALUES OF C_T

(See fig. 4)

Blade angle at 0.75 R	$\frac{V}{nD}$													
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1 0	1.1	1.2	1.3	1.4
°														
10	0.0620	0.0517	0.0419	0.0319	0.0202	---	---	---	---	---	---	---	---	---
11	.0674	.0573	.0472	.0368	.0251	---	---	---	---	---	---	---	---	---
12	.0721	.0627	.0524	.0419	.0298	0.0171	---	---	---	---	---	---	---	---
13	.0767	.0675	.0573	.0466	.0348	.0222	---	---	---	---	---	---	---	---
14	.0811	.0721	.0620	.0512	.0398	.0271	0.0148	---	---	---	---	---	---	---
15	.0847	.0760	.0662	.0558	.0447	.0321	.0197	---	---	---	---	---	---	---
16	.0876	.0792	.0704	.0601	.0498	.0378	.0252	0.0133	---	---	---	---	---	---
17	.0887	.0820	.0737	.0645	.0547	.0434	.0309	.0188	---	---	---	---	---	---
18	.0905	.0844	.0772	.0686	.0597	.0491	.0371	.0247	0.0137	---	---	---	---	---
19	.0920	.0867	.0806	.0730	.0649	.0549	.0433	.0307	.0194	---	---	---	---	---
20	.0934	.0894	.0841	.0773	.0697	.0301	.0492	.0368	.0255	0.0132	---	---	---	---
21	.0947	.0920	.0874	.0818	.0745	.0651	.0546	.0429	.0316	.0188	---	---	---	---
22	.0947	.0932	.0897	.0855	.0789	.0698	.0600	.0494	.0376	.0247	0.0138	---	---	---
23	.0947	.0945	.0915	.0901	.0829	.0745	.0650	.0546	.0436	.0308	.0197	---	---	---
24	.0942	.0942	.0924	.0902	.0865	.0785	.0696	.0602	.0495	.0369	.0257	0.0130	---	---
25	.0949	.0942	.0927	.0917	.0894	.0825	.0739	.0654	.0551	.0429	.0318	.0188	---	---
26	.0956	.0949	.0944	.0938	.0918	.0861	.0783	.0707	.0606	.0491	.0380	.0252	0.0147	---
27	.0961	.0948	.0957	.0951	.0940	.0896	.0824	.0755	.0658	.0553	.0441	.0324	.0213	0.0103
28	.0980	.0955	.0950	.0949	.0946	.0928	.0862	.0802	.0708	.0612	.0505	.0402	.0287	.0168

TABLE XIV

CABIN MONOPLANE WITH J-5 ENGINE

VALUES OF C_P

Blade angle at 0.75 R	$\frac{V}{nD}$													
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4
°														
10	0.0219	0.0206	0.0195	0.0181	0.0143	0.0086	0.0045	---	---	---	---	---	---	---
11	.0245	.0235	.0225	.0211	.0175	.0118	.0070	---	---	---	---	---	---	---
12	.0270	.0265	.0256	.0242	.0205	.0150	.0095	0.0019	---	---	---	---	---	---
13	.0296	.0294	.0287	.0272	.0237	.0182	.0124	.0051	---	---	---	---	---	---
14	.0323	.0324	.0318	.0302	.0268	.0215	.0156	.0085	0.0003	---	---	---	---	---
15	.0347	.0352	.0348	.0333	.0302	.0250	.0191	.0121	.0047	---	---	---	---	---
16	.0371	.0380	.0380	.0365	.0338	.0291	.0233	.0161	.0091	---	---	---	---	---
17	.0396	.0406	.0409	.0399	.0375	.0334	.0278	.0208	.0138	0.0043	---	---	---	---
18	.0421	.0434	.0441	.0433	.0416	.0380	.0329	.0258	.0187	.0093	---	---	---	---
19	.0451	.0465	.0474	.0471	.0460	.0429	.0382	.0311	.0238	.0144	0.0049	---	---	---
20	.0484	.0501	.0511	.0511	.0503	.0476	.0434	.0366	.0295	.0197	.0103	---	---	---
21	.0523	.0541	.0551	.0555	.0549	.0523	.0484	.0422	.0353	.0254	.0161	0.0046	---	---
22	.0567	.0586	.0593	.0600	.0593	.0570	.0534	.0479	.0413	.0313	.0221	.0102	---	---
23	.0619	.0634	.0637	.0644	.0637	.0618	.0584	.0537	.0475	.0376	.0284	.0162	0.0052	---
24	.0678	.0685	.0683	.0685	.0680	.0663	.0634	.0595	.0537	.0441	.0349	.0226	.0118	---
25	.0747	.0739	.0728	.0722	.0721	.0710	.0684	.0653	.0598	.0508	.0419	.0298	.0190	0.0058
26	.0824	.0794	.0774	.0757	.0760	.0755	.0738	.0711	.0659	.0578	.0492	.0379	.0270	.0140
27	.0907	.0850	.0818	.0791	.0799	.0801	.0792	.0769	.0720	.0650	.0567	.0467	.0358	.0230
28	.0993	.0905	.0864	.0824	.0837	.0846	.0847	.0826	.0780	.0721	.0646	.0559	.0452	.0330

TABLE XV

CABIN MONOPLANE WITH J-5 ENGINE

VALUES OF η

Bladge angle at 0.75 R	$\frac{V}{nD}$													
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4
°														
10	0.283	0.502	0.645	0.704	0.705	---	---	---	---	---	---	---	---	---
11	.275	.488	.630	.699	.716	---	---	---	---	---	---	---	---	---
12	.267	.473	.614	.693	.726	0.685	---	---	---	---	---	---	---	---
13	.259	.459	.599	.686	.734	.730	---	---	---	---	---	---	---	---
14	.251	.445	.585	.678	.739	.756	0.662	---	---	---	---	---	---	---
15	.244	.432	.571	.670	.740	.771	.721	---	---	---	---	---	---	---
16	.236	.417	.556	.659	.736	.779	.758	0.660	---	---	---	---	---	---
17	.224	.404	.541	.647	.729	.779	.779	.724	---	---	---	---	---	---
18	.215	.389	.525	.634	.718	.775	.790	.765	0.658	---	---	---	---	---
19	.204	.373	.510	.620	.705	.768	.794	.790	.732	---	---	---	---	---
20	.193	.357	.494	.605	.693	.758	.794	.805	.777	0.671	---	---	---	---
21	.181	.340	.476	.590	.679	.747	.790	.813	.805	.741	---	---	---	---
22	.167	.318	.454	.570	.665	.735	.786	.815	.820	.788	0.685	---	---	---
23	.153	.298	.431	.560	.651	.723	.779	.814	.827	.818	.763	---	---	---
24	.139	.275	.406	.527	.636	.710	.769	.809	.830	.837	.810	0.693	---	---
25	.127	.255	.382	.508	.620	.697	.756	.802	.830	.845	.835	.758	---	---
26	.116	.239	.366	.495	.604	.684	.743	.795	.827	.849	.849	.800	0.706	---
27	.106	.223	.351	.481	.588	.671	.728	.786	.823	.850	.856	.834	.775	0.625
28	.099	.211	.330	.461	.566	.658	.712	.776	.817	.849	.860	.863	.825	.713

TABLE XVI

CABIN MONOPLANE WITH J-5 ENGINE

VALUES OF C_S

Blade angle at 0.75 R	$\frac{V}{nD}$													
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4
°														
10	0.211	0.430	0.650	0.890	1.160	1.535								
11	.209	.423	.637	.869	1.125	1.450								
12	.205	.413	.623	.846	1.091	1.392	1.821							
13	.201	.403	.610	.827	1.063	1.347	1.722							
14	.197	.394	.598	.808	1.037	1.301	1.634	2.076						
15	.193	.387	.585	.790	1.010	1.259	1.554	1.939						
16	.190	.380	.574	.775	.986	1.218	1.489	1.826	2.358					
17	.189	.375	.564	.760	.963	1.181	1.431	1.733	2.182					
18	.187	.371	.555	.747	.944	1.148	1.384	1.659	2.030	2.568				
19	.185	.368	.546	.735	.926	1.120	1.343	1.597	1.908	2.348				
20	.182	.363	.538	.723	.910	1.100	1.308	1.545	1.817	2.189	2.725			
21	.179	.359	.530	.710	.895	1.082	1.280	1.500	1.746	2.073	2.516			
22	.175	.353	.523	.700	.881	1.065	1.255	1.464	1.692	1.990	2.371	2.920		
23	.171	.348	.517	.690	.870	1.050	1.232	1.432	1.650	1.922	2.253	2.716		
24	.168	.343	.510	.680	.858	1.037	1.212	1.405	1.612	1.867	2.150	2.550	3.065	
25	.164	.337	.504	.674	.846	1.023	1.193	1.380	1.580	1.816	2.069	2.420	2.830	
26	.161	.331	.499	.669	.835	1.008	1.174	1.359	1.549	1.769	2.002	2.310	2.656	3.186
27	.159	.326	.493	.665	.826	.993	1.159	1.337	1.524	1.728	1.947	2.217	2.523	2.954
28	.156	.320	.486	.662	.818	.979	1.144	1.317	1.500	1.690	1.900	2.133	2.412	2.782

TABLE XVII

CABIN FUSELAGE WITH J-5 ENGINE

VALUES OF C_T

(See fig. 5)

Blade angle at 0.75 R	$\frac{V}{nD}$													
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4
°														
10	0.0621	0.0525	0.0421	0.0305	0.0190									
11	.0667	.0574	.0470	.0361	.0239									
12	.0721	.0620	.0518	.0412	.0288	0.0158								
13	.0769	.0669	.0566	.0464	.0341	.0215								
14	.0811	.0715	.0612	.0516	.0395	.0273	0.0138							
15	.0850	.0756	.0662	.0567	.0453	.0331	.0195							
16	.0877	.0795	.0707	.0618	.0510	.0390	.0251	0.0135						
17	.0902	.0830	.0750	.0669	.0562	.0445	.0311	.0190						
18	.0911	.0864	.0794	.0720	.0618	.0500	.0372	.0249	0.0130					
19	.0925	.0890	.0832	.0766	.0676	.0555	.0433	.0312	.0188					
20	.0941	.0913	.0869	.0813	.0724	.0612	.0495	.0373	.0249	0.0132				
21	.0950	.0933	.0904	.0851	.0772	.0670	.0556	.0437	.0312	.0193				
22	.0967	.0950	.0930	.0886	.0818	.0727	.0613	.0498	.0377	.0258	0.0138			
23	.0969	.0955	.0943	.0918	.0856	.0778	.0671	.0561	.0441	.0325	.0202			
24	.0959	.0957	.0950	.0924	.0888	.0823	.0725	.0618	.0502	.0390	.0270	0.0149		
25	.0964	.0956	.0950	.0935	.0912	.0860	.0773	.0673	.0563	.0455	.0337	.0213		
26	.0966	.0955	.0955	.0946	.0925	.0887	.0820	.0729	.0622	.0517	.0401	.0279	0.0172	
27	.0974	.0961	.0963	.0956	.0936	.0913	.0865	.0779	.0680	.0576	.0466	.0348	.0239	
28	.0989	.0979	.0970	.0962	.0949	.0931	.0898	.0831	.0735	.0630	.0525	.0414	.0304	0.0194

TABLE XVIII

CABIN FUSELAGE WITH J-5 ENGINE

VALUES OF C_P

Bladge angle at 0.75 R	$\frac{V}{nD}$													
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4
°														
10	0.0225	0.0215	0.0201	0.0175	0.0136	0.0078	0.0016							
11	.0247	.0240	.0228	.0206	.0169	.0114	.0047							
12	.0272	.0265	.0255	.0236	.0201	.0149	.0080	0.0008						
13	.0297	.0292	.0284	.0267	.0235	.0185	.0114	.0044						
14	.0322	.0320	.0312	.0299	.0270	.0221	.0150	.0080						
15	.0347	.0346	.0343	.0331	.0307	.0260	.0190	.0120	0.0035					
16	.0370	.0374	.0374	.0365	.0345	.0300	.0230	.0163	.0075					
17	.0394	.0402	.0404	.0401	.0382	.0340	.0275	.0208	.0121	0.0030				
18	.0418	.0432	.0437	.0439	.0422	.0382	.0323	.0256	.0174	.0080				
19	.0447	.0465	.0472	.0478	.0466	.0427	.0374	.0310	.0228	.0134	0.0029			
20	.0485	.0503	.0513	.0520	.0506	.0476	.0428	.0364	.0285	.0191	.0085			
21	.0531	.0546	.0556	.0562	.0550	.0527	.0485	.0423	.0345	.0255	.0145	0.0035		
22	.0586	.0595	.0604	.0606	.0596	.0580	.0540	.0483	.0409	.0321	.0211	.0100		
23	.0650	.0650	.0652	.0652	.0640	.0631	.0598	.0545	.0475	.0391	.0283	.0171	0.0050	
24	.0716	.0708	.0700	.0691	.0683	.0680	.0653	.0606	.0541	.0462	.0358	.0245	.0125	
25	.0790	.0765	.0746	.0732	.0725	.0725	.0704	.0665	.0608	.0535	.0435	.0324	.0205	0.0073
26	.0866	.0826	.0796	.0772	.0762	.0765	.0755	.0725	.0675	.0609	.0513	.0405	.0289	.0157
27	.0946	.0890	.0845	.0812	.0800	.0806	.0806	.0783	.0744	.0682	.0596	.0490	.0375	.0246
28	.1030	.0955	.0895	.0851	.0837	.0845	.0855	.0841	.0810	.0754	.0676	.0574	.0459	.0334

TABLE XIX

CABIN FUSELAGE WITH J-5 ENGINE

VALUES OF η

Blade angle at 0.75 R	$\frac{V}{nD}$													
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4
°														
10	0.276	0.488	0.628	0.698	0.698									
11	.270	.478	.618	.700	.708									
12	.265	.468	.610	.699	.717	0.635								
13	.259	.458	.598	.695	.725	.699								
14	.252	.447	.588	.690	.732	.740	0.645							
15	.245	.437	.579	.685	.737	.765	.718							
16	.237	.425	.567	.677	.739	.780	.765	0.662						
17	.229	.413	.557	.667	.736	.786	.792	.732						
18	.218	.400	.545	.656	.732	.786	.806	.777	0.674					
19	.207	.383	.529	.641	.725	.780	.810	.805	.743					
20	.194	.363	.508	.625	.715	.771	.809	.820	.787	0.689				
21	.179	.342	.488	.606	.702	.763	.802	.826	.815	.758				
22	.165	.319	.462	.585	.686	.752	.794	.825	.830	.803	0.720			
23	.149	.294	.434	.563	.669	.740	.785	.823	.836	.830	.786			
24	.134	.270	.407	.535	.650	.726	.777	.816	.835	.845	.829	0.729		
25	.122	.249	.382	.510	.629	.712	.769	.810	.833	.850	.851	.789		
26	.112	.231	.360	.490	.607	.696	.760	.804	.829	.849	.860	.826	0.775	
27	.103	.216	.342	.471	.585	.680	.751	.796	.823	.844	.860	.853	.830	
28	.096	.205	.325	.452	.566	.661	.736	.790	.817	.836	.855	.865	.860	0.815

TABLE XX

CABIN FUSELAGE WITH J-5 ENGINE

VALUES OF C_S

Blade angle at 0.75 R	$\frac{V}{nD}$													
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4
°														
10	0.212	0.430	0.660	0.890	1.160	1.530								
11	.209	.420	.642	.868	1.121	1.458								
12	.205	.411	.630	.845	1.088	1.391	1.830							
13	.201	.405	.616	.829	1.058	1.340	1.729							
14	.200	.398	.602	.810	1.030	1.294	1.633	2.126						
15	.199	.390	.590	.791	1.004	1.253	1.550	1.941						
16	.194	.384	.580	.778	.980	1.218	1.482	1.810	2.410					
17	.191	.379	.570	.761	.960	1.181	1.430	1.718	2.205					
18	.189	.373	.560	.749	.940	1.150	1.388	1.649	2.045	2.663				
19	.187	.370	.552	.737	.921	1.127	1.350	1.594	1.923	2.380				
20	.184	.364	.545	.724	.910	1.106	1.321	1.552	1.835	2.200	2.892			
21	.180	.358	.533	.710	.891	1.078	1.283	1.502	1.758	2.077	2.590			
22	.179	.350	.527	.697	.880	1.058	1.254	1.462	1.698	1.981	2.390	3.030		
23	.174	.343	.519	.688	.868	1.040	1.229	1.430	1.650	1.910	2.250	2.720		
24	.170	.340	.510	.680	.858	1.025	1.208	1.400	1.610	1.848	2.141	2.515	3.175	
25	.168	.332	.505	.672	.848	1.011	1.188	1.371	1.576	1.791	2.058	2.375	2.888	
26	.164	.326	.499	.668	.839	1.000	1.170	1.350	1.542	1.746	1.990	2.271	2.680	3.263
27	.161	.322	.491	.660	.830	.990	1.158	1.330	1.513	1.709	1.932	2.190	2.520	2.963
28	.159	.319	.487	.652	.820	.980	1.141	1.310	1.482	1.676	1.888	2.112	2.385	2.730

TABLE XXI

CABIN FUSELAGE WITH COMPLETELY COWLED J-5 ENGINE

VALUES OF C_T

(See fig. 6)

Blade angle at 0.75 R	$\frac{V}{nD}$														
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
°															
10	0.0588	0.0505	0.0408	0.0316	0.0195										
11	.0641	.0562	.0463	.0365	.0247										
12	.0700	.0615	.0517	.0415	.0297	0.0172									
13	.0745	.0666	.0570	.0464	.0347	.0227									
14	.0794	.0714	.0622	.0513	.0397	.0280	0.0151								
15	.0833	.0759	.0672	.0563	.0451	.0332	.0207								
16	.0860	.0792	.0715	.0611	.0504	.0386	.0275	0.0141							
17	.0876	.0816	.0755	.0661	.0556	.0441	.0321	.0199							
18	.0884	.0842	.0795	.0709	.0608	.0497	.0382	.0261	0.0150						
19	.0900	.0864	.0830	.0755	.0659	.0554	.0440	.0322	.0209						
20	.0916	.0895	.0865	.0800	.0709	.0607	.0498	.0384	.0268	0.0148					
21	.0933	.0920	.0897	.0844	.0757	.0659	.0556	.0441	.0327	.0206					
22	.0951	.0946	.0928	.0881	.0803	.0711	.0610	.0496	.0385	.0265	0.0149				
23	.0944	.0937	.0933	.0905	.0843	.0757	.0661	.0551	.0441	.0324	.0209				
24	.0933	.0922	.0918	.0903	.0870	.0800	.0711	.0604	.0498	.0384	.0269	0.0154			
25	.0932	.0920	.0913	.0894	.0874	.0834	.0757	.0657	.0553	.0440	.0330	.0213			
26	.0935	.0911	.0902	.0891	.0886	.0865	.0800	.0710	.0608	.0498	.0388	.0274	0.0171		
27	.0937	.0915	.0905	.0895	.0897	.0889	.0842	.0764	.0663	.0556	.0452	.0339	.0235	0.0130	
28	.0954	.0921	.0914	.0906	.0906	.0909	.0880	.0819	.0719	.0613	.0511	.0401	.0301	.0190	0.0092

TABLE XXII

CABIN FUSELAGE WITH COMPLETELY COWLED J-5 ENGINE

VALUES OF C_P

Blade angle at 0.75 R	$\frac{V}{nD}$														
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
°															
10	0.0216	0.0210	0.0198	0.0181	0.0142	0.0086	0.0030	------	------	------	------	------	------	------	------
11	.0240	.0237	.0227	.0210	.0173	.0121	.0060	------	------	------	------	------	------	------	------
12	.0265	.0264	.0256	.0240	.0204	.0155	.0090	0.0013	------	------	------	------	------	------	------
13	.0290	.0291	.0285	.0270	.0236	.0189	.0121	.0048	------	------	------	------	------	------	------
14	.0315	.0318	.0315	.0301	.0268	.0223	.0155	.0083	------	------	------	------	------	------	------
15	.0340	.0345	.0345	.0333	.0303	.0258	.0192	.0121	0.0048	------	------	------	------	------	------
16	.0363	.0371	.0374	.0365	.0338	.0295	.0233	.0163	.0094	------	------	------	------	------	------
17	.0386	.0397	.0404	.0399	.0376	.0236	.0276	.0209	.0140	0.0045	------	------	------	------	------
18	.0411	.0425	.0435	.0433	.0415	.0379	.0325	.0260	.0190	.0100	------	------	------	------	------
19	.0441	.0455	.0468	.0469	.0455	.0424	.0375	.0313	.0240	.0154	0.0051	------	------	------	------
20	.0477	.0493	.0505	.0507	.0498	.0469	.0427	.0368	.0294	.0208	.0108	------	------	------	------
21	.0521	.0535	.0547	.0550	.0541	.0515	.0480	.0422	.0351	.0265	.0166	0.0060	------	------	------
22	.0573	.0582	.0591	.0592	.0585	.0562	.0531	.0478	.0410	.0325	.0226	.0121	0.0007	------	------
23	.0629	.0633	.0636	.0635	.0628	.0608	.0582	.0534	.0471	.0386	.0290	.0183	.0074	------	------
24	.0691	.0686	.0682	.0675	.0669	.0654	.0633	.0590	.0534	.0450	.0355	.0249	.0141	0.0017	------
25	.0758	.0739	.0725	.0711	.0705	.0696	.0683	.0646	.0595	.0514	.0425	.0318	.0212	.0091	------
26	.0827	.0792	.0767	.0747	.0740	.0739	.0731	.0703	.0656	.0581	.0492	.0392	.0287	.0168	0.0026
27	.0901	.0847	.0808	.0782	.0772	.0780	.0780	.0761	.0718	.0650	.0571	.0470	.0366	.0248	.0113
28	.0978	.0903	.0848	.0816	.0802	.0820	.0827	.0820	.0780	.0719	.0647	.0550	.0448	.0330	.0202

TABLE XXIII

CABIN FUSELAGE WITH COMPLETELY COWLED J-5 ENGINE

VALUES OF η

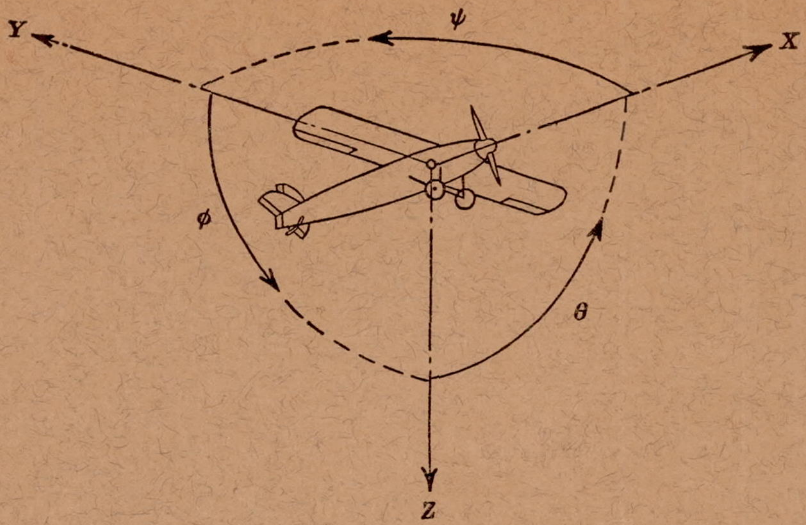
Blade angle at 0.75 R	$\frac{V}{nD}$														
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
°															
10	0.272	0.481	0.618	0.699	0.686	------	------	------	------	------	------	------	------	------	------
11	.267	.474	.612	.695	.715	------	------	------	------	------	------	------	------	------	------
12	.264	.466	.606	.691	.728	0.667	------	------	------	------	------	------	------	------	------
13	.257	.458	.600	.687	.735	.721	------	------	------	------	------	------	------	------	------
14	.252	.449	.592	.682	.741	.753	0.680	------	------	------	------	------	------	------	------
15	.245	.440	.584	.676	.745	.772	.754	------	------	------	------	------	------	------	------
16	.237	.427	.574	.670	.745	.784	.795	0.692	------	------	------	------	------	------	------
17	.227	.411	.561	.663	.740	.788	.815	.761	------	------	------	------	------	------	------
18	.215	.396	.548	.655	.733	.787	.823	.802	0.710	------	------	------	------	------	------
19	.204	.380	.532	.644	.724	.784	.821	.822	.785	------	------	------	------	------	------
20	.192	.363	.514	.631	.712	.776	.817	.834	.822	0.713	------	------	------	------	------
21	.179	.344	.492	.614	.700	.768	.811	.835	.840	.779	------	------	------	------	------
22	.166	.325	.471	.595	.686	.759	.804	.831	.845	.816	0.724	------	------	------	------
23	.150	.296	.440	.570	671	.747	.795	.825	.844	.840	.792	------	------	------	------
24	.135	.269	.404	.535	.650	.734	.786	.819	.840	.853	.833	0.743	------	------	------
25	.123	.249	.378	.503	.620	.719	.776	.814	.837	.857	.856	.804	------	------	------
26	.113	.230	.353	.477	.599	.702	.766	.808	.835	.858	.867	.841	0.775	------	------
27	.104	.216	.336	.458	.581	.684	.756	.803	.832	.855	.871	.865	.835	0.735	------
28	.098	.204	.323	.444	.565	.665	.745	.799	.830	.852	.870	.875	.873	.807	0.681

TABLE XXIV

CABIN FUSELAGE WITH COMPLETELY COWLED J-5 ENGINE

VALUES OF C_S

Blade angle at 0.75 R	$\frac{V}{nD}$														
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
°															
10	0.212	0.437	0.675	0.927	1.201	1.541	------	------	------	------	------	------	------	------	------
11	.210	.423	.643	.877	1.138	1.454	------	------	------	------	------	------	------	------	------
12	.207	.411	.619	.840	1.090	1.380	1.835	------	------	------	------	------	------	------	------
13	.201	.401	.602	.810	1.054	1.324	1.721	------	------	------	------	------	------	------	------
14	.199	.395	.590	.791	1.027	1.280	1.625	2.109	------	------	------	------	------	------	------
15	.197	.389	.580	.779	1.004	1.241	1.544	1.943	------	------	------	------	------	------	------
16	.192	.382	.575	.765	.984	1.210	1.478	1.816	2.363	------	------	------	------	------	------
17	.190	.379	.568	.755	.961	1.180	1.425	1.722	2.177	------	------	------	------	------	------
18	.187	.371	.560	.745	.941	1.151	1.380	1.653	2.029	2.546	------	------	------	------	------
19	.184	.369	.551	.734	.924	1.126	1.345	1.598	1.912	2.313	------	------	------	------	------
20	.180	.364	.544	.722	.909	1.103	1.313	1.550	1.822	2.155	2.749	------	------	------	------
21	.175	.358	.535	.710	.895	1.083	1.285	1.509	1.754	2.048	2.520	------	------	------	------
22	.174	.350	.527	.700	.882	1.065	1.258	1.470	1.699	1.971	2.358	2.909	------	------	------
23	.171	.346	.520	.691	.871	1.049	1.234	1.438	1.655	1.910	2.237	2.675	------	------	------
24	.170	.341	.514	.684	.860	1.034	1.214	1.410	1.617	1.858	2.141	2.514	3.061	------	------
25	.168	.337	.508	.678	.849	1.020	1.198	1.385	1.584	1.809	2.060	2.387	2.814	3.510	------
26	.166	.331	.501	.673	.839	1.008	1.183	1.361	1.553	1.763	1.999	2.285	2.641	3.155	------
27	.163	.327	.496	.669	.830	.997	1.170	1.340	1.527	1.725	1.947	2.203	2.518	2.930	3.546
28	.159	.321	.490	.664	.823	.987	1.159	1.317	1.500	1.691	1.904	2.137	2.420	2.770	3.350



Positive directions of axes and angles (forces and moments) are shown by arrows

Axis		Force (parallel to axis) symbol	Moment about axis			Angle		Velocities	
Designation	Symbol		Designation	Symbol	Positive direction	Designation	Symbol	Linear (component along axis)	Angular
Longitudinal	X	X	Rolling	L	$Y \longrightarrow Z$	Roll	ϕ	u	p
Lateral	Y	Y	Pitching	M	$Z \longrightarrow X$	Pitch	θ	v	q
Normal	Z	Z	Yawing	N	$X \longrightarrow Y$	Yaw	ψ	w	r

Absolute coefficients of moment

$C_l = \frac{L}{qbS}$ (rolling) $C_m = \frac{M}{qcS}$ (pitching) $C_n = \frac{N}{qbS}$ (yawing)

Angle of set of control surface (relative to neutral position), δ. (Indicate surface by proper subscript.)

4. PROPELLER SYMBOLS

D, Diameter
p, Geometric pitch
p/D, Pitch ratio
V', Inflow velocity
V_s, Slipstream velocity
T, Thrust, absolute coefficient $C_T = \frac{T}{\rho n^2 D^4}$
Q, Torque, absolute coefficient $C_Q = \frac{Q}{\rho n^2 D^5}$

P, Power, absolute coefficient $C_P = \frac{P}{\rho n^3 D^5}$
C_s, Speed-power coefficient $= \sqrt[5]{\frac{\rho V^5}{P n^2}}$
η, Efficiency
n, Revolutions per second, r.p.s.
Φ, Effective helix angle $= \tan^{-1}\left(\frac{V}{2\pi r n}\right)$

5. NUMERICAL RELATIONS

1 hp. = 76.04 kg-m/s = 550 ft-lb./sec.
1 metric horsepower = 1.0132 hp.
1 m.p.h. = 0.4470 m.p.s.
1 m.p.s. = 2.2369 m.p.h.

1 lb. = 0.4536 kg.
1 kg = 2.2046 lb.
1 mi. = 1,609.35 m = 5,280 ft.
1 m = 3.2808 ft.

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